REPORTS OF THE NATIONAL CENTER FOR SCIENCE EDUCATION

DEFENDING THE TEACHING OF EVOLUTION IN THE PUBLIC SCHOOLS

Volume 20, Number 4 JUL/AUG, 2000

CONTINUES *NCSE REPORTS* & *CREATION/EVOLUTION*

Introduction to Creationist Mathematics

Are the Odds Against Life Too Great?

Beyond Kansas: Evolution at the Elections

New NCSE Clergy Program

CONTENTS

REPORTS OF THE NATIONAL CENTER FOR SCIENCE EDUCATION
DEFENDING THE TEACHING OF EVOLUTION IN THE PUBLIC SCHOOLS

CONTINUES *NCSE REPORTS* & *CREATION/EVOLUTION*

VOLUME 20, NR 4, JUL/AUG 2000
ISSN 1064-2358

Views expressed are those of their authors and do not necessarily reflect the views of NCSE. *RNCSE* is published 6 times a year.

Address editorial correspondence to the editor. Style guidelines can be found on the inside back cover of this issue. Write to the publisher regarding address changes, missing issues, purchases of back issues, reprint rights, and related issues.

Cover by Janet Dreyer.

FROM THE EDITOR

"There are three kinds of lies: lies, damned lies, and statistics." In his autobiography, Mark Twain attributed this statement to British Prime Minister Benjamin Disraeli, but the prevailing attitudes toward quantitative reasoning have not changed much since then. At the same time that we recognize the value and necessity of backing up our assertions with "facts and figures", we are distrustful of numerical arguments made by others — particularly by our opponents. This attitude was summed up perhaps most succinctly, if not eloquently, in George W Bush's characterization of Al Gore's presentation of statistics during their first presidential debate as "fuzzy math".

This attitude is reinforced by a lack of training in numerical reasoning. Traditional mathematics education has stressed computation and "number facts", and parallel to the movement in science education reform, mathematics education now includes a greater emphasis on using basic facts for solving problems and supporting conclusions (*see, for example, the Quantitative Literacy programs of the American Statistical Association,<http://www.amstat.org/education/k12material.html>, or the Standards and Principles published by the National Council of Teachers of Mathematics, <http://www.nctm.org/standards/>*). When he wrote *Innumeracy: Mathematical Illiteracy and Its Consequences* in 1990, John Allen Paulos argued that our national inability to understand numbers and the basics of probability theory results in the persistence of numerous social problems — misinformed governmental policies, confused personal decisions, and, most important to NCSE, an increased susceptibility to pseudosciences of all kinds.

Applied Mathematics

In this issue we print a number of articles that share a numerical theme. It is no surprise to most people familiar with modern anti-evolutionism that its proponents use a blizzard of numbers to support their contention that the natural origin of some structure or the natural construction of some biochemical compound is "impossible". Of course, these probabilities are usually computed correctly, even though the conclusions are incorrect. The *real* problem is frequently their authors' failure to understand (or explain) the importance of their starting assumptions and simplifying suppositions for the validity of their conclusions. The mathematical musings of these anti-evolutionists clearly illustrate that the real problem is not so much with computational accuracy as with quantitative *reasoning*.

Thomas Robson explores these issues in his article on creationist pseudomathematics. Although the underlying principles of probability theory are relatively simple, he argues that an adequate refutation of the anti-evolutionists' misuse of probability theory often requires a detailed and highly technical discussion of both probability and the scientific processes that are responsible for the "improbable" phenomenon under discussion.

David Bailey's article examines the probability arguments made against the natural origin of hemoglobin. He applies the logic to something that we can — and, in some places, regularly do — observe directly: the formation of snowflakes. Snowflakes manifest nearly infinite amounts of variation as a result of a few, simple natural processes; thus each and every snowflake is an object with a very low probability and a high degree of complexity.

Finally, Richard Carrier has allowed us to adapt an article from his web site which contains a "who's who" of those who advance mathematical anti-evolutionary arguments. He presents examples both of legitimate scientific work that is misrepresented to attack evolution and of creationist and other pseudoscientific misuses of quantitative reasoning.

The delightful illustrations that accompany these articles are the work of a talented NCSE volunteer, Janet Dreyer, as is the image that appears on the cover. For more information on Janet's work, visit her web site at <http://www.genies.com>.

In the News

Evolution was featured in several elections — perhaps most notably in Kansas, where the state Board of Education was significantly changed after voters responded to the gutting of state exiting examination standards. Standards in Kansas are likely to change again. In other states, evolution did better … or worse. Glenn Branch reports.

Draft science education standards in Pennsylvania were changed to introduce a requirement that teachers present "evidence that … does not support the theory of evolution". State Board of Education officials are defending the change in language, but activists are complaining that evolution is singled out for special treatment and that the only curriculum materials that discuss "evidence against" evolution are produced by creationist organizations. Andrew Petto reports.

There was much furor over the "Intelligent Design" research center — the Michael Polanyi Center — at Baylor University. A multidisciplinary team of scholars examined the program, the operations, and the results of the Polanyi Center recently, and made recommendations for a significant reorganization. However, the team's report was only the beginning of the story. Eugenie Scott reports.

At Home

If you have called or received a note from the NCSE office lately, you may have noticed new voices and names connected to the communication. Meet the new staff and get the details of the changes in this issue. There is also a picture of the office staff — you can't tell the players apart without a program!

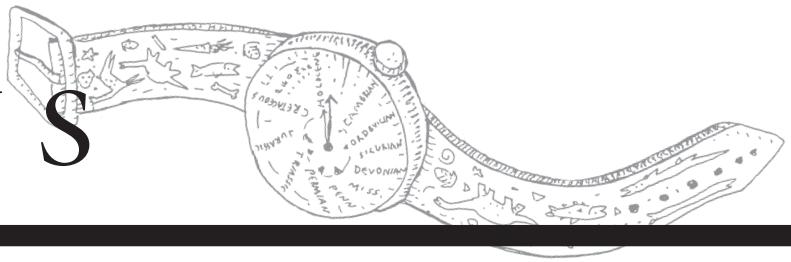
We also learned that many of you received an extra copy of our last issue. Don't be shy! Share that extra one with a neighbor, friend, or colleague. It's a great way to help NCSE grow.

This issue of *RNCSE* is so packed with information that we couldn't manage to squeeze the usual members' pages in. Look for them — and our exceptional book reviews, listings of useful resources, and exciting short features — in the next issue!

Anj Petto

RNCSE 20 (4) was printed in March 2001.

NEWS



Intelligent Design in Pratt County, Kansas

Molleen Matsumura
Network Project Director

Immediately after the Kansas State Board of Education's August 1999 adoption of science content standards that opened the door to teaching creationism (*RNCSE* 1999; 19 [3]: 6, 19 [4]: 7–9), speculation began about which local schools would walk through that doorway. Within a few weeks, NCSE heard that in Pratt County, Kansas, local activists were pressing for adoption of the "intelligent design" textbook *Of Pandas and People* (*RNCSE* 1999; 19 [4]: 5). Parents in the district contacted NCSE, and, with help from NCSE staff and Kansas Citizens for Science, provided teachers and administrators with extensive information about the flaws of the book. Even though some local school board members were sympathetic to teaching "intelligent design", *Pandas* was not adopted. But Pratt County's creationists were undaunted.

When the effort to adopt *Pandas* in Pratt County failed, local school board members began discussing whether to add discussions of "ID theory" to draft curriculum guidelines developed by local teachers. Opinion on the board was divided, and months passed as the document circulated back and forth among a curriculum committee, the board, and high-school science teachers. At one point, the teachers, determined to teach good science, responded to the board's concerns by suggesting that students could write ungraded research papers expressing their opinions of evolution. However, observers of Pratt's school board meetings told NCSE that some members said that the state Board of Education had given them a mandate to teach "intelligent design". The Superintendent of Education was instructed to continue a "dialog" with teachers, and activists pressed the issue in the local newspaper (*see "Misquoted scientists speak out" below; also see various archived articles at <http://www.pratttribune.com>, which contains interesting reading, including many letters to the editor from other parts of the state*).

On November 7, three new, pro-evolution candidates were elected to the state Board of Education, making the majority of the board pro-evolution; the new members promised that evolution would be restored to state science standards (Kansas City *Star*, November 14, 2000). With a disappearing "mandate", ID supporters were under increased pressure to act. On November 27, the Pratt County School Board voted 4–2 (with one member absent) to adopt standards requiring students to "know … [t]here are different scientific perspectives regarding the prevailing textbook evidence used to support the theory of evolution" (Pratt *Tribune,* November 28, 2000). As rewritten by the Pratt County School Board, the curriculum called for using resources frequently recommended by "intelligent design" proponents in the classroom.

Observers told NCSE that local board members who opposed the changes asked whether advice had been sought from the school district's attorney and the state regents (who administer statewide assessments), and were told that no such action had been taken. After the vote, board president Bruce Pinkall told the Kansas City *Star*, "I'm more concerned with the effect on the staff and the perception of their work and the lack of support from the board for their work."

District parents have contacted the Kansas affiliate of the American Civil Liberties Union to explore the possibility of suing the district. Others have told NCSE that they hope to change the composition of the board in spring 2001, and then bring the district curriculum into harmony with revised state science standards. NCSE will keep its members informed of new developments.

[*NCSE thanks Brad Williamson and Liz Craig for information used in this article.*]

Misquoted Scientists Speak Out

Molleen Matsumura
Network Project Director

When an effort is under way to force creationism into a school district's curriculum, it is almost inevitable that at least one evolutionary scientist will be quoted as "admitting" that the theory is about to collapse. Often, NCSE helps local activists by sending them reprints or photocopies of the original quotation in context, or copies of articles we have published on the topic (*see "NCSE sets the record straight", p 7*) . In Pratt, Kansas, the confusion was so extreme that NCSE notified the scientists concerned, and they themselves responded.

A Classic Lack of Context

On August 25, 2000, some members of Kansas Citizens for Science wrote to NCSE when the Pratt *Tribune* published an opinion essay in which "intelligent design" activist Chris Mammoliti contended, "If Intelligent Design must be censored because it has a philosophy consistent with theism, shouldn't Darwinian evolution be censored because it has a philosophy consistent with atheism?" <http://www.pratttribune.com/display/inn_news/news9.txt>. In support of his view, Mammoliti quoted an article in the May 13 *National Post* by Michael Ruse, a philosopher and scientist who had been a key witness in the *McLean v Arkansas* trial concerning an anti-evolution law. Ruse was selectively quoted as stating that "Evolution is a religion."

What Mammoliti failed to report is that Ruse's article castigated those who he believes treat evolution as a religion. He had written, in part,

> You might think that the time has come to save evolution from the evolutionists.
>
> Darwinism is a terrific theory that stimulates research in every area of the life sciences. ... Surely this is enough.
>
> There is no need to make a religion of evolution. On its own merits, evolution as science is just that — good, tough, forward-looking science, which should be taught as a matter of course to all children…. [W]e should recognize when people are going beyond the strict science, moving into moral and social claims, thinking of their theory as an all-embracing world picture….
>
> … The Creationists are wrong in their Creationism, but they are right in at least one of their criticisms. Evolution, Darwinian evolution, is wonderful science. Let us teach it to our children. And, in the classroom, let us leave it at that… (downloaded from <http://www.nationalpost.com> on August 25, 2000; no longer available on site).

When NCSE sent Ruse a copy of Mammoliti's essay, he wrote to the Pratt *Tribune*. In his reply, published on September 6, Ruse remarked with his customary irony:

> Word has reached me that my name is not entirely unknown in the distant land of Kansas, where the conflict between science and religion rages like a wildfire in Montana. In particular, my writings are being used by the Creationists — the enthusiasts for reading the Bible absolutely literally — to support the case for qualifying (or outrightly removing) the teaching of evolution in science classes, in the publicly supported schools of the state…. I do feel a certain cognitive dissonance (as we say in the trade)…. For the past quarter century, in article after article, book after book, I have argued that Creationism is false science and bad religion….

Ruse continued:

> It would be natural therefore if I were to take my time showing in detail how I have been misrepresented, quoted selectively and out of context, making me apparently say things the very opposite to that which I intend…. But it would be more profitable if I were to explain just what position I do really take….
>
> …[A]s science, Creationism is simply not science. Creationism, in whatever variant, appeals to miracles — to divine interventions…. They do not and cannot fall under the purview of science, which by its nature is confined to the dimension of experience as governed by natural regularity or law.
>
> In my opinion, far worse than its failure as science is the fact that Creationism is (as I said above) bad religion….

Ruse made it clear that his criticisms of creationism apply equally to "intelligent design theory", commenting:

> The enthusiasts for so-called Intelligent Design claim that the organic world is so complex that mere law could not explain its origination. But why, if one invokes God for the wonderfully complex, should one excuse God for the appallingly simple?

After giving examples of both atheists and devout Christians who interpret evolution in religious terms, Ruse spoke directly to the issue on which he had been misquoted:

> *[M]y most important point — one which those who misuse my ideas conveniently omit or forget* — is that there is no need for evolution, for Darwinism, to be treated as religion. You can talk about evolution without bringing in moral messages and stories about ultimate meanings — and this is precisely what is going on in modern professional evolutionary circles today, including the professional evolutionary circles of Kansas today… <http://www.pratttribune.com/archives/index.inn?loc=detail&doc=/2000/September/6-512-news7.txt> (emphasis added).

SOME OF THE STORIES IN OUR NEXT ISSUE

Dinosaurs and Birds
NCSE president Kevin Padian explains the controversy over the theropod hypothesis

Very like a Whale
Ray Sutera discusses the transitional forms in cetacean phylogeny

Sermon under the Mount
A great-great-grandson of Darwin goes spelunking with Kurt Wise

Confusion Spreads to the Curriculum

The importance of such misquotations is that ultimately they affect decisions about what will be taught in science classes. In Pratt, school board members sympathetic to "intelligent design" relied on such misinformation when they altered the curriculum submitted by science teachers (*see "Intelligent design in Pratt County, Kansas", p 4*). Their addition of a book review from the journal *Nature* (Coyne 1998) reflected the fact that creationists have used this and other scientists' articles to "prove" that textbook authors are perpetrating a hoax when they cite changes in peppered moth populations as an example of natural selection (for example, Wells and Richards 2000, Wells 2000, Wieland 1999).

When NCSE told Jerry A Coyne, Professor of Ecology and Evolution at the University of Chicago, how his article was being misused, he contacted fellow scientist Bruce Grant, Professor of Biology at the College of William and Mary in Virginia. Coyne and Grant both wrote letters that were published in the Pratt *Tribune*. In his letter of December 13, Grant said in part:

> …[C]harges of fraud [have been] directed at evolutionists for attributing changes in the colors of peppered moths to natural selection. As I am one of the evolutionary biologists who study peppered moths, I feel obliged to comment. Charges of fraud cannot be left unchallenged….
>
> …Of the several factors known to produce evolutionary change, only natural selection is consistent with the patterns of the changes we see occurring in moth populations….
>
> We still have work to do. We do not all agree about the relative roles of contributing factors, such as the flow of genes…, … where on trees moths might hide from predators, … and so on…. Such wrangling is the norm, and … [o]ur debates have never been secret. For recent overviews of the controversies, please see <http://www.wm.edu/biology/melanism.pdf> or <http://www.els.net/elsonline/html/A0001788.html>. Yet, unwarranted charges of fraud, fakery and cover-ups repeatedly appear in letters printed in newspapers….<http://www.pratttribune.com/archives/index.inn?loc=detail&doc=/2000/December/13-653-news92.txt>.

Since Coyne's 1998 article was not only misquoted, but recommended for classroom use as "evidence *against* evolution", his December 6 letter is particularly important and NCSE obtained permission to reprint it in full, as follows:

> I have learned that the Pratt school board, apparently responding to creationist pressure, has recently revised its 10th-grade biology curriculum to include material that encourages students to question the theory of evolution. In reading the standards, I see that one of my articles — an article constantly misrepresented by creationists — is included as a supplementary reading used to cast doubt on evolution.
>
> Except for a few creationist dissenters, the community of professional biologists has long accepted evolution as an essential theory supported by innumerable pieces of evidence. To make students think otherwise is as harmful as urging them to question the value of antibiotics because there are a few people who believe in spiritual healing.
>
> My article appended to the Pratt standards is a re-evaluation of a classic evolutionary story in which rapid changes in the proportions of color forms of peppered moths occurred in only about 100 years. This evolutionary change is thought to be a response to air pollution, changes in the colors of trees, and increased bird predation. My only problem with the peppered-moth story is that I am not certain whether scientists have identified the precise agent causing the natural selection and evolutionary change. It may well be bird predators, but the experiments leave room for doubt.
>
> Creationists such as Jonathan Wells claim that my criticism of these experiments casts strong doubt on Darwinism. But this characterization is false. All of us in the peppered-moth debate agree that the moth story is a sound example of evolution produced by natural selection. My call for additional research on the moths has been wrongly characterized by creationists as revealing some fatal flaw in the theory of evolution.
>
> In reality, the debate over what causes natural selection on moths is absolutely normal in our field. It is not uncommon for scientists to re-examine previous work and find it incomplete, or even wrong. This is the nor-

mal self-correcting mechanism of science. Textbook examples may be altered as additional data are found. Creationists, on the other hand, neither air their disagreements in public nor admit that they were wrong. This is because their goal is not to achieve scientific truth, but to expel evolution from the public schools.

It is a classic creationist tactic, as exemplified in Wells's book, *Icons of Evolution*, to assert that healthy scientific debate is really a sign that evolutionists are either committing fraud or buttressing a crumbling theory. In reality, evolution and natural selection are alive and well, with new supporting evidence arriving daily.

I strongly object to the use of my article by the Pratt school board to cast doubt on Darwinism. And I feel sorry for the students who are being misled by creationists into doubting one of the most vigorous and well-supported theories in biology.

Old tactic, new tactic

Misrepresentation of scientists' research and opinions is a problem that will continue as long as there is opposition to evolution and evolution education. Any one example is rather like the hydra, the mythical monster who grew 2 heads where one had been cut off: creationists invariably offer new misinformation when their claims are rebutted. Somewhat less is said about "Nebraska man" and Lucy's knee these days, and somewhat more is heard about peppered moths and 19th-century drawings of embryos. Meanwhile, the decapitated heads, like Medusa's, keep biting; for literally years after a creationist claim has been thoroughly refuted, grassroots activists around the country repeat it in opinion essays and testimony before school boards. If your local newspaper prints a letter claiming that scientists are "dishonest", or that they are "admitting" to "problems" with evolution, you will find that with some investigation (and possibly some help from NCSE) you can set the record straight.

The newer tactic is to select journal articles and reviews for classroom use, to be presented in a manner that recasts discussions *about* evolution as arguments *against* evolution. It will be important to monitor and analyze these occurrences, and explaining the issues to curriculum committees and school boards is likely to be more complex and time-consuming than answering a letter to the editor. NCSE can help by providing background information and sometimes, as we did in response to the situation in Pratt, by enlisting the scientists whose work is being misused. Please do not hesitate to contact us if this problem appears in your school district.

[*Thanks to John van Keppel, Jack Krebs, and Liz Craig for tracking and sharing newspaper articles and essays.*]

References

Coyne J. Not black and white [review of Majerus M, *Melanism: Evolution in Action*, Oxford: Oxford University Press, 1998]. *Nature* 1998; 396: 35–6.

Wells J. *Icons of Evolution.* Washington DC: Regnery Publishing, 2000.

Wells J, Richards JW. Lerner Report whitewashes bad science [press release of the Discovery Institute]. Available at <http://www.arn.org/docs/wells/jw_lerner1000.htm>.

Wieland C. Goodbye, peppered moths: A classic evolutionary story comes unstuck. *Creation Ex Nihilo* 1999 June–August; 21 (3): 56. Available at <http://www.answersingenesis.org/docs/4122.asp>.

NCSE Sets the Record Straight

Molleen Matsumura
Network Project Director

Over the years, NCSE has answered many requests for information about claims in creation science literature that scientists and defenders of evolution education have themselves denied the validity of evolution or called for teaching creationism. Even when they have been refuted, these claims are quoted again and again in letters and opinion pieces appearing in newspapers all over the country. Following is a list of articles NCSE has published explaining how misquotation or presentation out of context has distorted the statements of proponents of evolution. (Copies of all of these articles are still available from NCSE; write, call, or e-mail to request them.)

Britain, Troy. Just what do they say, Dr Morris? *RNCSE* 1999; 19 (1): 22–23.
Britain explains the context of quotations used by the first president of the Institute for Creation Research, Henry M Morris, in a March 1999 Back to Genesis seminar, noting that Morris said that 3000 similar quotations are collected in his book *That Their Words May Be Used Against Them* (Green Forest, AR: Master Books, 1998).

Cole, John R. Misquoted scientists respond. *Creation/Evolution* 1981; 6: 34–44.
Creation/Evolution editor John Cole presents out-of-context quo-

Misquotations on the Web

"Anti-evolutionists have a fondness for quoting authorities. Almost as strong as this fondness is their fondness for misquoting authorities." Thus Wesley Elsberry introduces the compilation of anti-evolutionist misquotations on his web site. Elsberry's database is conveniently searchable; misquotations may be retrieved by quoter, quoted, keywords in quotation, fragment of quotation, and source of quotation. It also allows the user to submit new misquotations to the compilation. To try it out, connect to <http://inia.cls.org/~welsberr/evobio/evc/quotes.html>.

tations of 6 scientists — Richard Lewontin, Niles Eldredge, Stephen Jay Gould, David M Raup, Laurie Godfrey, and Isaac Asimov — together with the original authors' remarks on what they really said.

Jukes, Thomas. Jukes responds to a request for permission to quote out of context. *NCSE Reports* 1988; 8 (2): 22.
A reprint of Thomas Jukes's February 3, 1988, letter refusing to give permission for ICR attorney Wendell Bird to quote him in *The Origin of Species Revisited* (New York: The Philosophical Library, 1988) "because by quoting out of context, the main thrust of our article is misrepresented."

McIver, Tom. Creationist misquotation of Darrow. *Creation/Evolution* 1988; 23: 1–13.
Anthropologist McIver traces the history of mistaken claims that Clarence Darrow, one of the defense attorneys in the Scopes trial, said that it was "bigotry" for schools to teach "only one theory" and exclaimed "Let them have both evolution and creation!"

Padian, Kevin. The Darwin legend. *RNCSE* 1996; 16 (1): 2, 8.
A review of James Moore's book (Grand Rapids [MI]: Baker Books, 1994) demolishing the myth that in a deathbed conversation with one Lady Hope, Charles Darwin confessed regret for publishing his theory of evolution. (Note that this is myth, not misquotation, and various creationist authors have also opposed propagation of the myth. However, the story reappears so frequently it is well worth mentioning here).

Scott, Eugenie C. Colin Patterson, cladistics, and creationists. *NCSE Reports* 1992; 12 (4): 14–15.
NCSE's Executive Director reports on creationists' misrepresenting as a critique of evolution Patterson's November 1981 presentation at the American Museum of Natural History, entitled "Can You Tell Me Anything About Evolution?", which was actually a discussion of different approaches to systematics.

Scott, Eugenie C. Cold comfort for creationists in Ruse talk. *NCSE Reports* 1993; 13 (2): 10–11.
NCSE's Executive Director sets the record straight on creationist exploitations of out-of-context quotations from a talk given by the philosopher Michael Ruse at an NCSE symposium at the February 13, 1993, meeting of the American Association for the Advancement of Science.

Tarzia, Wade. Cheering with the enemy, or boosting your mileage with the best from bad reviews. *RNCSE* 1999; 19 (3): 30–3.
Bad reviews by the science "establishment" are often worn as a badge of honor among anti-evolutionists. Tarzia shows how the publisher's web site for *Forbidden Archaeology* takes this tactic one step further by gleaning positive-sounding excerpts from negative reviews, giving the false impression that reviewers found significant merit in the work.

Alabama to Ditch Disclaimer?

Molleen Matsumura
Network Project Director

In 1995, Alabama's state Board of Education fired its own "shot heard 'round the world" when it adopted science content standards that called for teaching evolution as "theory" rather than "fact" (*see* NCSE Reports *1995; 15 [1]: 4, 5 and* NCSE Reports *1995; 15 [2]: 3*). Following a suggestion in a "minority report" by Textbook Commission members who complained that mainstream biology textbook treated evolution as "fact", the board adopted an evolution "disclaimer" to be pasted into all biology textbooks (*see sidebar on page 9 for references to criticisms of the disclaimer*). At a highly charged meeting during which then-governor Fob James said that people ought to read the Bible for explanations of life's diversity, James pantomimed evolution by walking like an ape and gradually standing up straighter. (Later, James used discretionary funds to purchase Phillip Johnson's first anti-evolution book, *Darwin on Trial*, for distribution to Alabama's science teachers. NCSE, People for the American Way, and the National Association of Biology Teachers responded by sending the teachers information on the scientific, educational, and constitutional issues.)

Alabama's Board of Education was not the first to adopt an anti-evolution statement for insertion in textbooks. In September 1983, the Texas Board of Education issued rules that read in part "Textbooks presented for adoption which treat the subject of evolution substantively in explaining the historical origins of man … must carry a statement on an introductory page that any material on evolution… is clearly presented as theory rather than verified" (cited in Mattox 1984, in which the rules were deemed unconstitutional). However, the Alabama disclaimer carefully avoided religious references in even the generalized form found in the Texas rules (which mentioned "young people['s]…search for meanings of their human existence") and it inspired a rash of imitations in school districts around the country.

The Alabama disclaimer was repeated verbatim in legislation introduced in Washington in 1997, and most recently was adopted by Oklahoma's Textbook Commission late in 1999 (*see* RNCSE *1997; 17 [5]: 7, 1999; 19 [5]: 7–8*). Within the state, the teaching of evolution was seriously undermined: many teachers avoid teaching the subject at all, and the current standards offer little guidance to those who dare to teach it.

The Alabama Board of Education periodically revises content standards in all subjects, and in October 2000 an appoint-

ed writing committee released a first draft of "Alabama Course of Study: Science" (ACOSS) for public comment; scientists who had advocated better coverage of evolution in the 1995 ACOSS found it significantly improved. On January 11, 2001, the Department of Education released the new, revised version of ACOSS. Supporters of good science teaching encouraged the Board of Education to adopt standards that reflect the central importance of the theory of evolution. Their message to fellow members was, "If you live in Alabama, or have friends or colleagues in Alabama, please contact NCSE so we can work with them! Not only would improved standards help Alabama's children, but dropping the disclaimer would set a good example to every state." The state Board of Education approved the new ACOSS on February 8, 2001.

NCSE members and friends in Alabama worked hard to improve coverage of evolution in the new ACOSS and hope that it will render the disclaimer obsolete. (The disclaimer is not a part of science education standards, but was instituted as a part of the textbook approval process.) One reason for optimism is that a board member who voted for the disclaimer in 1995 has stated that it should be discontinued; another is the state government's current emphasis on attracting high-tech businesses, which often shun areas that they perceive as anti-science (*see, for example,* RNCSE *1999; 19 [4]: 10–15*).

References

Mattox J [Attorney-General of Texas]. Re: Whether certain rules of the State Board of Education concerning the treatment of the subject of evolution in textbooks violate the Establishment Clause of the United States Constitution. Opinion No JM-134, issued March 12, 1984.

[*Thanks to Scott Brande, Robert D Collins, and David Kopaska-Merkel for information used in this article. If you would like to help in Alabama, send an e-mail message to Eric Meikle at meikle@ncseweb.org.*]

Baylor's Polanyi Center in Turmoil

Eugenie C Scott
NCSE Executive Director

Baylor University's Michael Polanyi Center has been stripped of its name and subjected to intensive reorganization, after a lengthy debate over the existence of the "intelligent design" think tank on the Baptist school's campus.

The controversy began during the spring of 2000 when faculty members expressed their displeasure at the establishment of the Michael Polanyi Center (MPC) without faculty input (*see* RNCSE *20 [1–2]: 15–16).* Particularly displeased were members of the science faculty, who considered the "intelligent design" (ID) focus of the center to be a thinly veiled form of creation science. Because of faculty criticism, Baylor's President Robert B Sloan Jr agreed to appoint an outside investigating committee.

Committee members visited the campus and interviewed representatives of all sides on September 9 and 10, 2000, and the chair of the committee issued a report on October 17. Written in conciliatory language, the report nonetheless was decidedly lukewarm about the MPC. Although ID claims scientific standing, the committee's report placed the MPC's appropriate mission squarely within the realm of the philosophy of science, as considering "the relationship between the sciences and religion". The committee clearly stated that the Baylor Institute for Faith and Learning (IFL), the institute in which the MPC was housed, should take the university's lead when it came to science and religion issues, and encouraged a broader range of scholarship in this area beyond just ID.

> [Science and religion scholarship] ... can best be fostered by the University's Institute for Faith and Learning where it seems to be naturally at home. In pursuing this mission, room should be made for a variety of approaches and topics. It would clearly be too restrictive on the part of the Institute to focus attention in this area on a single theme only, such as the design inference.

In its recommendations, the committee continued its lukewarm assessment of the MPC and ID theory. It recognized

Criticisms of the Alabama Disclaimer

Brande S, Frandsen JC. The evolution/creation controversy during the 1995 Alabama science textbook adoptions. *Journal of the Alabama Academy of Science* 1997; 68 (1): 59–76.

Dawkins R. The "Alabama insert": A study in ignorance and dishonesty. *Journal of the Alabama Academy of Science* 1997; 68 (1): 1–16. Also available on NCSE's web site at <http://www.ncseweb.org/resources/articles/8642_richard_dawkins_on_the_alabama_ 1_2_2001.asp>.

Frandsen JC, Brande S. An analysis of the 1995 Alabama draft and adopted Course of Study: Science. *Journal of the Alabama Academy of Science* 1997; 68 (1): 38–58.

Miller KR. Dissecting the disclaimer. *RNCSE* 2000; 20 (3): 30–3. Also available on NCSE's web site at <http://www.ncseweb.org/resources/articles/5438_dissecting_the_disclaimer_ 12_7_2000.asp>.

Scott EC. Textbook authors join NCSE in defending evolution education. *RNCSE* 1999; 19 (1): 9–11. Also available on NCSE's web site in the news section of <http://www.ncseweb.org/newsletter.asp?volume=19&number=1>.

[*All of these articles are available from NCSE; write, telephone, or e-mail to request photocopies.*]

> … research on the logical structure of mathematical arguments for intelligent design to have a legitimate claim to a place in current discussions of the relations of religion and the sciences. Although this work, involving as it does technical issues in the theory of probability, is relatively recent in origin and has thus only just begun to receive response in professional journals (*see, for example, the essay by Elliott Sober in* Philosophy of Science *1999; 66: 472–88*), the Institute should be free, if it chooses, to include in its coverage this line of work, when carried out professionally.

Because the cited article by Sober (and coauthors) is strongly critical of ID, and because the IFL (rather than the MPC) is called upon to include, "if it chooses", only ID research that is carried out *professionally*, the implication is clear that the committee did not have much confidence in the current scholarly status of ID theory.

The committee recommended that an advisory committee of Baylor faculty be formed "to assist in planning and reviewing the science and religion component of the Institute". It also called for dropping the name "Michael Polanyi", as the center named for him did not reflect the fact that Polanyi rejected the idea of an agent as creator.

So the Michael Polanyi Center was stripped of its name, placed squarely under the jurisdiction of a philosophy and religion administrative unit, subjected to a faculty advisory committee, and not very subtly put on notice that ID lacked status as a scholarly enterprise.

Nonetheless, on October 17, Director Dembski issued a stirring press release declaring victory for ID and the MPC. Although the Center was placed firmly under the aegis of the IFL, and it was the *IFL* that was encouraged to go beyond ID in its consideration of science and religion issues, Dembski's press release announced that the MPC had been given a broader mission. The stripping of the name "Polanyi" from the Center was spun as "the Center will therefore receive a new name to reflect this expanded vision". The admonition of the Center to conduct ID research only "when carried out professionally" juxtaposed with the citation of an article harshly critical of Dembski was transformed into "the triumph of intelligent design as a legitimate form of academic inquiry" and an "unqualified affirmation of my own work on intelligent design."

Although many reading the committee's report and Dembski's press release might question whether Dembski "got it", apparently another sentence in the press release got him in trouble. Baylor critics of the MPC would have preferred a more strongly worded committee report, but in general were satisfied with the results as a compromise between sides with strong disagreements. It appeared that perhaps peace could be restored after the committee's report had been issued. But in his press release, Dembski thumbed his nose at critics, shattering any possibility of effective interaction with a large percentage of the faculty. He gloated, "Dogmatic opponents of design who demanded the Center be shut down have met their Waterloo."

Through newspaper accounts and personal communications, NCSE learned that members of the science faculty and the Baylor Faculty Senate expressed outrage to President Sloan over Dembski's uncollegial behavior, and on October 19, the Director of the Institute for Faith and Learning, Michael Beaty, announced that "Dembski's actions after the release of the report compromised his ability to serve as director" and relieved him of his position. Dembski's associate, Bruce Gordon, described as holding "a PhD in the history and philosophy of physics from Northwestern University, as well as degrees in mathematics, philosophy, theology and piano performance", was appointed as interim director, although he has stated that he does not wish to be the permanent director.

On the same day, Dembski followed up with another press release responding to his dismissal. He claimed that the administration had called him on the carpet, asking that he withdraw his inflammatory press release. Dembski refused on the grounds that he meant what he had said "and that for me to retract it would be tantamount to giving in to the censorship and vilification against me that had been a constant feature since I arrived on campus. I could not and would not betray all that I have worked for in my professional career."

The inflammatory press release became for Dembski a matter of principle, and he accused the administration of "intellectual McCarthyism", a statement that is not likely to mend fences. Ironically, it was President Sloan who had established the MPC, defended it against a faculty outraged at the cavalier way in which it had been established, and supported Dembski all along. Now Dembski was accusing Sloan of "the utmost of bad faith", as if Sloan intended from the beginning to sack him: Dembski claimed that his refusal to withdraw an inflammatory press release "provided the fig leaf of justification for my removal". At the time of this writing, there was no reply from Sloan.

Dembski will continue at the rank at which he was hired, as an untenured "Associate Research Professor" in the Institute for Faith and Learning. The establishment of the MPC was seen as a major step toward achieving the 5-year objectives of the "Wedge" strategy outlined by the Discovery Institute and ID leader Phillip Johnson. This is a long-range plan to establish ID as both a scholarly

and a public enterprise, including a hoped-for establishment of an ID institute on a university campus. Baylor's placement of the members of the former Michael Polanyi Center in a relative academic backwater as a subsidiary of a faith and learning institute, and its barely civil recognition of ID as an area that has not achieved much scholarly support, hardly provides the academic credibility for ID sought by Wedge strategists.

As this issue of *RNCSE* went to press, an article entitled "Intelligent Design Movement Struggles with Identity Crisis" by Bruce Gordon, the interim director of what is now called The Baylor Science and Religion Project, appeared in *Research News & Opportunities in Science and Theology* (2001 January; 2 [1]: 9). Gordon writes:

> Design theory has had considerable difficulty gaining a hearing in academic contexts, as evidenced most recently by the whole Polanyi Center affair at Baylor University. One of the principal reasons for this resistance and controversy is not far to seek: design-theoretic research has been hijacked as part of a larger cultural and political movement. In particular, the theory has been prematurely drawn into discussions of public science education, where it has no business making an appearance without broad recognition from the scientific community that it is making a worthwhile contribution to our understanding of the natural world.

Later, in what is perhaps a swipe at Dembski's affiliation with the Discovery Institute's Center for the Renewal of Science and Culture, Gordon comments, "If design theory is to make a contribution in science, it must be worth pursuing on the basis of its own merits, not as an exercise in Christian 'cultural renewal,' the weight of which it cannot bear." In his final paragraph, he carefully delineates the nature of design theory's possible contribution to science: "[I]t is crucial to note that design theory is at best a supplementary consideration introduced alongside (or perhaps into, by way of modification) neo-Darwinian biology and self-organizational complexity theory. It does not mandate the replacement of these highly fruitful research paradigms, and to suggest that it does is just so much overblown, unwarranted, and ideologically driven rhetoric." Should Gordon's cautious attitude become more widely adopted by ID proponents, it might alleviate much of the controversy about the status of intelligent design.

The Michael Polanyi Center Peer Review Committee report is available on line at <http://baylor.edu/pfd/001017polanyi.pdf>. The Baylor administration responds at <http://pr.baylor.edu/feat.fcgi?2000.10.17.polanyi>.

Evolution and the Elections

Glenn Branch
NCSE Office Manager

In all the furor over the November 2000 elections, evolution received scant attention. Here is a sampling of news about evolution and the elections — some encouraging; some disquieting.

Alabama: Judge Roy S Moore was elected as Chief Justice of the Alabama Supreme Court with 55% of the vote. Moore is best known for defying a federal circuit court order to remove the Ten Commandments from the wall of his courtroom and to refrain from opening his court sessions with a prayer; he is also on record as deploring the teaching of evolution in public schools (*see* RNCSE *2000; 20 [1–2]: 20*).

Alaska: In his first political endeavor, NCSE member Neal Matson lost his bid for the Alaska State Senate in District Q. He kindly donated his leftover campaign funds to NCSE. Matson reports that creationism was not an issue in any Alaska election, although the Republican Party of Alaska believes that "Creation Science [should] be given equal representation with the other scientific theories in the classroom, and if evolution is taught, it should be presented as a theory" <http://www.alaskarepublicans.com/Platform.htm#Education>. The Democratic Party of Alaska does not mention creationism or evolution in its platform.

Colorado: Before the November election, the Colorado branch of the American Association of University Women asked congressional and state school board of education candidates about their position on teaching creationism as an alternative to the theory of evolution in public schools. Mark Udall, the Democratic candidate for Colorado's 2nd Congressional District, replied, "Establishing school curricula is a matter for the states and local school districts. However, I think it's essential that our children have the benefit of a thorough understanding of all the sciences and be fully informed about the continuing progress of scientific investigation and the basis for science's theories in all fields — including the theory of evolution" (see <http://www.coaauw.org/election2000/udall.html>). Udall defeated his Republican opponent, who did not respond to the questionnaire. Two Democratic candidates for the state board of education who agreed that creationism has no place in the public schools, Evie Hudak and Jared Polis, also were elected; Hudak's Republican opponent, Ron Marquez, held that "Creationism and the theory of evolution are both valid views of the beginning of life and should both be taught" (*see <http://www.coaauw.org/election2000/marquez.html>*).

Kansas: In August 1999, the Kansas state board of education voted 6–4 to adopt a creationist-influenced set of science standards (*see* RNCSE *1999; 19 [4]: 7–9, 10–15)*. The seats of 4 of the 6 board members who voted for the standards were up for election in 2000. Of those members, one (Scott Hill) moved out of Kansas, resigned his seat, and was ultimately replaced by a pro-evolution candidate; two (the president of the board, Linda Holloway, and Mary Douglass Brown) lost to pro-evolution candidates in primary elections; and one (Steve Abrams) won both the primary election and the general election (*see* RNCSE *2000; 20 [3]: 4–5*). Thus the incoming board opposes the current science standards by 7–3; incoming board members have said that one of their first actions will be to replace them with a set written by a 27-member committee of science teachers and professors. (The set of standards that the board replaced with its own version was the fifth draft prepared by an expert writing committee; this committee has written a sixth draft for adoption in January 2001 and posted it at <http://www.kabt.org/standards>.)

Nebraska: Rachel Bone was elected to the District 4 seat of the state board of education. The Lincoln *Journal Star* (November 3, 2000) reported that "if creationism were to become an issue before the board, [Bone] said she would defend teaching it in schools."

Ohio: State representative Ron Hood, who vowed in 1996 to keep reintroducing his "equal time for creationism" bill until it became state law, lost his seat to Democrat John Boccieri in a close race (51.9% to 48.1%). (*For the status of the bill, see "Updates", p 15. Steve Edinger reports on evolution education in Ohio in the next issue of* RNCSE.)

Vermont: Republican gubernatorial candidate Ruth Dwyer lost to incumbent governor (and physician) Howard Dean, by 37.9% to Dean's 50.4%. The Burlington *Free Press* quoted Dwyer as saying that it would be right for public schools to teach creationism if local citizens wanted them to (*see* RNCSE *2000; 20 [3]: 11*).

West Virginia: Senator Robert Byrd, former chair and ranking minority member of the powerful Senate Appropriations Committee, handily won re-election. In August, during a ceremony to dedicate a new radio telescope at the National Radio Astronomy Observatory in Green Bank, West Virginia, Byrd remarked, "I'm not a scientist, of course, but I have a querulous [*sic*] mind. That's why I read Darwin's *The Origin of Species.* That's why I read Darwin's *The Descent of Man*. He had something to say. It doesn't bother me to have it taught in schools. But why not teach the creation in the Book of Genesis, which was the greatest scientific thesis that was ever written?" (quoted in *Science and Government Report*, September 15, 2000).

National: In discussing Governor — and now President — George W Bush, *The New York Times* reported, "Characteristically, he does not believe in evolution — he says the jury is still out — but he does not actively disbelieve in it either; as a friend puts it, 'he doesn't really care about that kind of thing'" <http://www.nytimes.com/2000/10/29/politics/29BUSH.html>.

Canada: In late November, several Canadian newspapers reported that the Canadian Alliance candidate for prime minister, Stockwell Day, supports teaching creationism. While Day's party failed by far to win enough seats to install Day as prime minister, 38% of Canadians share his belief in creationism, according to a November 25 report in the Ottawa *Citizen*. The *Citizen* also reported that 43% of Canadians support teaching evolution and 40% say they "would be concerned if a prime minister had the opposite view that they held on creationism/evolution" (*see <http://www.ottawacitizen.com/national/001125/4935416.html>*). In a province-by-province breakdown, the strongest support for evolution, 49%, was reported in Quebec.

[*NCSE thanks Liz Craig, Steve Edinger, Peter Folger, Neal Matson, and John Stear for information used in this article.*]

Idaho Academy of Science Sponsors Evolution Short Course

Thanks to the tireless efforts of supporters of evolution around the state, the Idaho Academy of Sciences will present an Evolution Short Course at its annual meeting, to be held March 29–31, 2001, at Albertson College in Caldwell, Idaho. The course, Interdisciplinary Perspectives on Evolution: A Primer for Teachers, is designed for public school teachers and carries continuing education credit. The program is under development, but the current plans include the following presentations.

Introduction: Evolution Overview — Dr James C Munger and Dr Eric Yensen

Should Genesis Be Interpreted Literally? — Rabbi Dan Fink

Philosophy of Science — Dr Elizabeth Wakeman

Cosmological Evidence for an Old Universe — Dr James Dull

Geological Evidence for Evolution and an Old Earth — Dr Terry S Maley

Biological Evidence for Evolution — Dr James F Smith

Anthropological Evidence for Evolution — Dr Pat Derbidge

The Realms of Religion and Science — Dr Denny Clark

Legal Aspects of Teaching Creationism and Evolution — Jon Bauman

Panel Discussion

For more information, contact Dr Gary Bennett, SugarID@aol.com.

Creeping Creationism in Pennsylvania's Science Education Standards

Andrew J Petto
NCSE Editor

Pennsylvanians are preparing for their final opportunity to comment on draft standards for science and technology education from the Pennsylvania Department of Education (PDE). These standards are designed as educational benchmarks that will indicate the content and concepts that ought to be included in instruction at various grade levels. They are intended neither to prescribe curricula nor to serve as the basis for progress and exiting examinations. Two previous drafts were released in 1998 and 1999, and public comment and testimony led to reorganization and revisions.

The release of the third draft of the proposed standards in July 2000 generally strengthened the standards; however, the sections on evolution education were modified by PDE staff based on comments received in response to the previous drafts. The most egregious of these changes will require that teachers present "evidence that … does not support" the theory of evolution. The most significant changes in the standards appear in the table below.

The changes in the standards reflect 2 specific trends. First, there is a general de-emphasis on the explanatory power of evolution. The old standard asked students to know that evolution is the *cause* of the observed patterns of similarity and difference. The new standard eliminates this language in favor of standards that ask students to "describe", "explain", or "interpret" observations, but not their causes. Second, the standards in the Biological Sciences section specifically instruct students to challenge evolutionary theory in grade 10 (3.3.10.D) and grade 12 (3.3.12.D).

Why the Standards Changed

A line-by-line comparison of the third draft with the second shows significant changes in language only in areas related to evolution. Although standards in the Inquiry and Design section clearly set the stage for students to explore how scientific theories are constructed and how they respond to challenges, no other scientific theory is singled out for students to hear the evidence that "does not support" it. When Pennsylvania Board of Education Executive Director Peter Garland was interviewed on December 21, 2000, on WHYY-FM's *Radio Times*, he stated the PDE's position on the changes: that the new language models the practice of good science by teaching children how to evaluate evidence and to participate in the

Old Standard		New Standard	
Section 3.2: Inquiry and Design			
Standard	Text	Standard	Text
3.2.7.A.4	Integrate new information into existing theories and practice.	3.2.7.A.4	Explain how new information may change existing theories and practice.
3.2.10.A.4	Explain how new information may change existing theories and practice.	3.2.10.A.4	Integrate new information into existing theories and practice.
3.2.10.A.2	Know that science is limited to the study of *concrete* aspects of the world and the universe.	3.2.10.A.2	Know that science is limited to the study of *observable* aspects of the world and the universe.
Section 3.3: Biological Sciences			
3.3.10.D.1	Analyze evidence of fossil records, similarities in body structures, embryological studies and DNA studies that support the theory of evolution.	3.3.10.D.1	Analyze evidence of fossil records, similarities in body structures, embryological studies and DNA studies that support *or do not support* the theory of evolution.
3.3.10.A	Explain the causes of similarities and differences found among living things.	3.3.10.A	Explain the structural and functional similarities and differences found among living things.
n/a	No comparable standard	3.3.10.B.1	Describe the relationship between the structure of organic molecules and the function they serve in living organisms.
n/a	No comparable standard	3.3.10.B.3	Explain how cells store and use information to guide their functions.
n/a	No comparable standard	3.3.12.D.1	[A]nalyze the impact of new scientific facts on the theory of evolution.
Section 3.4: Earth Sciences			
3.4.12.A.3	[I]nterpret the geological evidence for evolution.	3.5.12.A.3	[I]nterpret the geological evidence support ing evolution to explain biological and astronomical changes.

process of applying evidence to existing models and theories. However, when asked why the standards should single out evolution in this way, he demurred and said that the standards were still subject to another round of citizen comments and further revisions.

According to a story in the Pittsburgh *Post-Gazette,* Dan Langan, a spokesman for the PDE, said the new phrases were inserted by members of the state Board of Education, but he did not identify who suggested the changes. If the standards are approved, Langan said, they would allow the teaching of creation theory alongside evolution in public school science classes. "'Under the proposed standards, there's room for science teachers to expose students to other theories,' Langan said. 'The degree to which that's done is up to local school districts'" ("Proposed rules boost teaching of creationism", November 29, 2000; <http://www.post-state/20001129creationism1.asp>).

State Representative Sam Rohrer (R-Berks) went further in his comments on *Radio Times.* Confusing the distinction between educational standards and curriculum, he took Garland to task for having the temerity to impose standards at all. Rohrer argued that the state constitution provided for local control over education and that the PDE had no authority to prescribe standards. As for evolution, Rohrer told the Philadelphia *Inquirer*: "I am not a scientist, … but I've done enough reading to know that the whole concept of natural selection and evolution is not science. It's not repeatable. It's a theory. You can talk about chemistry, physics — those things are all a matter of fact" ("State standards stir evolution–creation debate", December 3, 2000; B3, B5; <http://inq.philly.com/content/inquirer/2000/12/03/city/CREATE03.htm>).

But more disturbing than the statements of outspoken conservative Rohrer are the comments of the Pennsylvania Secretary of Education, Eugene Hickok. He told the Bucks County *Courier Times*: "Evolution is not a fact, it's a scientific theory." Hickok reasons that "because it's a theory, that means you have to test various hypotheses to support it or not support it". Teachers have always had the option to do that, he said ("Officials: Proposed standards don't change evolution policy", November 30, 2000; <http://www.phillyburbs.com/couriertimes/news/news%5Farchive/701981.htm>).

The difference, of course, is that the proposed standards are the first state-mandated requirement that evolution be taught at all. The inclusion of evolution in state science education standards for the first time means that local districts can no longer choose to ignore or avoid evolution and still claim to be in compliance with state education mandates. Despite Hickok's protestations, these standards *do* change things considerably. The proposed standards would *require* teachers to include evolution — and also anti-evolution materials — in the biology curriculum.

Why Be Concerned?

This is, indeed, the question we hear most often from well-meaning citizens. "After all", they say — echoing Garland's rationale — "isn't subjecting theories to criticism just how good science operates?" The modified standards do not sound like typical creationist fare to most people, prompting the Main Line *Times* to compare NCSE's Molleen Matsumura to "the hysterical anticommunists of the 1950s" who were obsessed with "Reds under the beds". In its editorial, the *Times* told its readers that "the hysterical evolutionists of today are no less afraid of shadowy Christians with Adams and Eves up their sleeves" ("Why are scientists working to keep ideas and debate out of our classrooms?", December 7, 2000; <http://www.zwire.com/site/news.cfm?BRD=1676&dept_id=43770&newsid=1153961&PAG=461&rfi=9>).

Most of the changed language does sound nonsectarian, but the issues raised are those that are well known to NCSE members as the special concerns of anti-evolutionists with a particular religious worldview — that creationism is a valid, competing scientific theory and should be included in the curriculum. The careful construction of the secular-sounding language would make this a difficult case to take to the public in most cases, except that proponents of the language throughout the state are, like Rohrer, quite candid in their public statements that they wish to insert creationism into the curriculum.

But the real danger here is not so much in the standards themselves: if curriculum development is left in the hands of well-trained teachers, they will find no scientifically or educationally respectable evidence that "does not support" evolution. The real danger is that districts that choose to look for curriculum materials to meet these standards — evidence against evolution, the impact of "new scientific facts" on the theory of evolution, the relationship between structure and function in organic molecules, and cellular storage and use of information — will be forced to turn to nonmainstream sources of curriculum materials.

Where do we find curriculum materials that meet these standards? Why, at the Discovery Institute's Center for the Renewal of Science and Culture, the Institute for Creation Research, and other creationist outfits. And books that promote these ideas come from publishers of frankly sectarian religious publications and of creationist books, like InterVarsity Press, Baker Book House, and Regnery Publishing.

In essence, if teachers in Pennsylvania *must* teach evidence that "does not support" evolution, then they *must* use creationist materials from CRSC, ICR, and the like. The result is that the

current draft of the Pennsylvania Standards for Science and Technology Education contains a *de facto* requirement that students learn creationism — there is no other way to describe the curriculum materials they will have to use if local school districts must comply with the current draft standards on evolution.

The PDE will provide citizens with one more 30-day comment period to respond to the current draft. NCSE members in Pennsylvania have joined with other concerned citizens and organizations to spread the word and to muster support for a return to good science education standards with an appropriate treatment of evolution. Joining this effort in Pennsylvania are the Pennsylvania ACLU, the Pennsylvania Alliance for Democracy, the Freedom to Learn Network, Pennsylvania members of the American Institute of Biological Sciences, and a number of biomedical researchers and science-related corporations located in the state. The education committees of the state legislature also plan to hold hearings in the current session. State Representative Connie Williams (D-Montgomery), who serves on the House Education Committee with Rohrer, has indicated her support for evolution education and opposition to the current language. Dates for the comment period and legislative hearings were not set as of press time.

[*The Radio Times discussion on WHYY also features NCSE Editor Anj Petto and is available at <http://whyy.org/ rameta/RT/RT20001221_20.ram>. Thanks to Laura Blain, Dave Caplan, Louise Doskow, Stephen Katz, Bruce Levine, Stephen C Meyers, Clark Moeller, Robbie Recenes, Charlie Sturm, Lisamarie Windham, and a host of others for help with this story.*]

Author's Address

Andrew J Petto
Division of Liberal Arts
University of the Arts
320 S Broad St
Philadelphia PA 19102-4994
ajpetto@uarts.edu

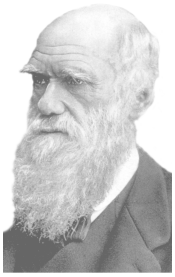
UPDATES

Canada, Ontario: On Sunday, October 29, 2000, the Ottawa *Citizen* reported that Ontario students receive little instruction in evolution: "The new provincial curriculum only addresses evolution in a single course — advanced biology, designed for Grade 12 students who will study biology or biochemistry in university" (see "Evolution nearly extinct in classroom: New science curriculum tries to avoid controversy", reposted on the *National Post* web site at <http://www.nationalpost.com/news/national/story.html?f=/stories/20001030/445748.html>). The article states that Ontario is "following the lead of many of the United States" and adds that, although evolution is not explicitly banned, teachers report that covering the many topics they are required to teach leaves little time for evolution. According to the article, many Ontario students reach college unprepared for biology courses.

Minnesota, Faribault: Attorneys representing creationist teacher Rodney LeVake appealed a decision ruling that school administrators had the right to reassign him to a general science class where he would not teach about evolution (*see* RNCSE *2000; 20 [1–2]: 13–14*). NCSE will inform readers of further developments.

Minnesota, Dakota County: A parent in School District 196 (Rosemount–Apple Valley–Eagan) has been trying to donate copies of 2 "intelligent design" books, *Darwin on Trial* and *Darwin's Black Box*, to all of the district's secondary school media centers.

Darwin Day 2001



In order to promote the rich history of achievement over the past 150 years in scientific and philosophical communities, a global "Darwin Day Celebration" has been organized. The event is to be held annually on or near the birthday of Charles Darwin, February 12, by all interested individuals, groups, and organizations to enhance the recognition of scholarly achievements among the public. To learn about the development of a Darwin Day Program or to participate in and contribute to the program, please visit the Darwin Day website currently under development at <http://www.darwinday.org>.

The Darwin Day Website initiative is open to all interested parties. We invite all groups, organizations, and individuals to take full advantage of the site and participate in what we hope becomes a united effort to champion science throughout the world. Sponsors of the program include groups, businesses, organizations, and individuals within the scientific and philosophical communities. Program Directors are available to work with you, to share your ideas and material with others, and to develop and maintain the site for years to come. The central location afforded by the Darwin Day website will serve as an anchor point to gather and develop the program further and to gain exposure and raise awareness about one of the most worthwhile celebrations to be launched in the new millennium.

To receive periodic updates about Darwin Day and news items from our website, you may join an electronic mailing list by sending a blank email to darwinday-subscribe@egroups.com or go to <http://www.egroups.com/group/darwinday> and click Subscribe.

[*Contributed by Ken Harding.*]

NCSE NEWS

NCSE Begins Clergy Program

Molleen Matsumura
Network Project Director

A vital aspect of NCSE's work is cooperation with organizations sharing common concerns. The number and diversity of groups supporting evolution education is reflected by the nearly 100 position statements NCSE collected in *Voices for Evolution* — a number that has grown since the second edition was published in 1995.

NCSE has built close working relationships with a number of these organizations, which frequently rely on our expertise in evolution/creation issues, tell individuals needing help to call NCSE, and in turn provide us with needed assistance. However, while our ties with scientific, educational, and civil-liberties organizations are well-developed, our formal ties with religious organizations are less extensive. We also need to develop resources that will be useful to clergy, religious educators, and other people of faith who wish to be voices for evolution both publicly and within their faiths.

Our first steps in this direction have been significant. NCSE contributed to the development of evolution resources on the web site of the Dialogue for Science, Ethics, and Religion (DoSER) of the American Association for the Advancement of Science <http://www.aaas.org/spp/dser/evolution/>. Since then, NCSE's Executive Director Eugenie C Scott has joined the DoSER Advisory Committee and participated in a panel discussion of "The Creation/Evolution Controversy: A Philosophical Examination" at a Science and Religion Workshop held by the Center for Theology and the Natural Sciences in June 2000 (*see <http://www.ctns.org>*).

Now we are taking further steps to build a grassroots network of religious leaders. NCSE will develop and distribute materials that congregational leaders and religious educators can use to inform themselves and their communities about evolution/creation issues. We will also inform interested individuals of opportunities to speak out for evolution education, since NCSE's experience has been that religious individuals speaking from their faith's perspective are most effective in pointing out that evolution is not inherently anti-religious.

In order to identify people who want to be involved and find

The donations were rejected by district media specialists because the books do not match criteria of appropriateness and usefulness in support of the biology curriculum. In September 2000, following the district's appeal process, a reconsideration committee made up of parents, students, and teachers voted 7–6 to accept *Darwin on Trial* and 6–6 to reject *Darwin's Black Box*. These actions were appealed to the Board of Education by the parent and by groups of media specialists and science teachers. A teacher in the district told NCSE that the decision is not expected to have an impact on the way teachers present evolution.

New Mexico, Silver City: A high school "Creation Club" is being formed to counter evolution being taught in science classes. Students have been distributing creationist literature on campus. Such clubs are permitted under the Equal Access Act, with certain restrictions, including that the club be entirely directed and made up of students and school staff ("nonschool persons may not direct, conduct, control, or regularly attend activities of student groups"). NCSE members are monitoring the club in Silver City because of the reported involvement of a local preacher, which would be impermissible under the Act.

New York: According to an August 19, 2000, article in *The New York Times*, National Heritage Academies, Inc, is among the organizations that have submitted bids to operate schools in New York City under a privatization program. Although NCSE has learned that National Heritage Academies is not under consideration for the program, activists report that founders of another National Heritage Academies school in Rochester, New York, who were reported as intending "to teach students about creationism as a scientifically based theory competing with the theory of evolution" (*see* The New York Times*, February 18, 2000*), have agreed not to teach creationism.

Ohio: In September 2000, it was confirmed that the Ohio House Education Committee will not meet again until further notice. HB 679, the bill requiring that "evidence against evolution" be taught whenever evolution is taught, was not acted upon by the committee this year and is not expected to be considered before the legislature adjourns (*see* RNCSE *2000; 20 [1–2]: 21*). However, concerned NCSE members report that several legislators expressed their approval of the bill and new legislation may be introduced in a future session. Meanwhile, the bill's chief sponsor, Ron Hood, lost his bid for reelection (*see "Evolution and the elections", p 11. Read Steve Edinger's report on the Ohio elections in the next issue of* RNCSE.)

West Virginia, **Kanawha County:** A parent has filed a complaint with the Kanawha County

out what they need, NCSE has sent a questionnaire to a pilot group of clergy in Kansas asking about conditions in their communities and their willingness to work on this issue. We received a very good response and are now working with other organizations to reach more interested individuals. We are also working with an increasing number of interfaith groups and social action agencies of some denominations.

Now you can help. Tell NCSE whether you or someone you know is interested in learning more about our clergy network — or in telling someone else about it; write to Molleen Matsumura at interfaith@ncseweb.org, or at NCSE, PO Box 9477, Berkeley CA 94709-0477.

[*NCSE wishes to thank Caroline McKnight and the Rev Bob Meneilly of the Kansas MAINstream Coalition for their assistance.*]

Board of Education claiming that science textbooks used there contain "false and fraudulent" information about evolution. The parent and 30 cosigners opposed to evolution assert that the textbooks violate state law because they are outdated or inaccurate. As evidence to support their claims, they cite the recent book *Icons of Evolution*. Similarly-based attacks on evolution education are appearing in other locations as well. This most recent event resembles several others in this county. In 1999, a middle school mathematics teacher tried to get the board to approve a resolution allowing teachers to criticize "evolutionism". In 2000, a local group tried to get the Board to distribute copies of the "intelligent design text" *Of Pandas and People*. The board rejected both of these efforts. (*See Karl Fezer's article in* RNCSE *2000; 20 [1–2]: 16–9.*)

[*NCSE thanks John Cole, Steve Edinger, Martha Laties, Terry Moore, and Jeff Seaver for information used in this article.*]

More Changes at NCSE

by Molleen Matsumura
Network Project Director

Dear Friends,

This article is taking the form of a letter because it is not only about "news".

As of February 1, 2001, I begin a leave of absence from NCSE, temporarily continuing in charge of a single project. After that, it is uncertain whether I will return. This means I must make many farewells.

I have worked for NCSE for over 7 years, and my work here has never been "just a job", or even a "career", but far more. I have worked with countless people coping with tremendous challenges in an important cause. My colleagues and NCSE's members are friends and compatriots. On balance, it is a *very* good thing that I have too many friends to say an individual "good-bye" to every one.

I am proud of what I have accomplished at NCSE, and of having helped bring the organization through demanding times of change and growth. I'm grateful for the trust and support that our members have given me: You are the ones who have taken risks and made sacrifices, facing possible ostracism of yourselves or your children, giving up time and resources.

You are passionate and creative people. Most of you find many ways to work on such issues as good public education, honest science, and civil liberties for all. I am certain that in many instances our paths will cross again. That's wonderful!

With warm regards,
Molleen

KAMINER ON CREATIONISM

In her recent book *Sleeping with Extra-Terrestrials: The Rise of Irrationalism and the Perils of Piety* (New York: Pantheon, 1999), Wendy Kaminer devotes a few pages to creationism, culminating in the following lapidary paragraph:

> The Bible's account of creation may be embraced by nearly half of all Americans, but creationism is not simply a religious doctrine. Like the belief that recreational sex is sinful, it is a sectarian one. People of various faiths share various scientific, religious, and ethical beliefs — that the earth is round and God exists and murder is immoral; but they differ in their beliefs about the origins of the universe. Teaching creationism in the public schools is wrong, not only because it is like describing the moon as a wheel of green cheese but because it is like declaring that Christ was the son of God (p 76).

Office Biz

Glenn Branch
NCSE Office Manager

Double Vision?

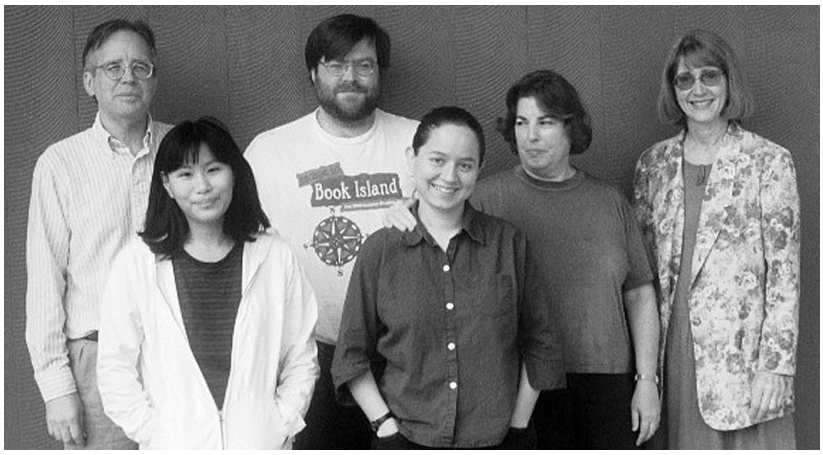
Due to an error in compiling the mailing list for the last issue of *RNCSE*, some members may have received 2 copies of *RNCSE* 20: 3. If you are one of these members, please give your extra copy to anyone who you think would find it interesting and valuable. There is no better way of introducing people to the benefits of NCSE membership than by showing them the newsletter!

Sustainerships Clarified

Starting in 1999, NCSE began to offer its members the opportunity to become sustainers. Sustainers of NCSE donate a fixed amount, usually by credit card, every month. Sustainers get the advantage of spacing their donations out over the course of the year, while NCSE gets the advantage of being able to count on the fixed income. The sustainer program has been an unmitigated success to date, with over 150 sustainers contributing between $5.00 and $100.00 per month. And we would love for *you* to become a sustainer too! Either fill out the form in the fundraising letter you should have recently received or simply give us a call at 1-800-290-6006.

Unfortunately, there has been some confusion, both in and out of the NCSE office, about the precise terms of the sustainer policy. In the announcement for the sustainer program, new sustainers were told that their membership/subscription will be automatically renewed after their 12th contribution. However, their *RNCSE* mailing labels continued to show an expiration date, and they continued to receive expiration notices. To remedy the situation, sustainers now will receive *RNCSE* as long as they are sustainers. They will no longer receive expiration notices, and the abbreviation SUST will appear instead of an expiration date on the mailing label. Sustainers will continue to receive our twice-yearly fundraising letter — not because they need to renew their memberships/subscriptions but because we like to keep them informed on recent developments and to offer them the chance to change their donation level if they wish.

As always, if you have any questions about your sustainership or your subscription to *RNCSE*, please get in touch with me by calling 1-800-290-6006 or by e-mailing to ncseoffice@ncseweb.org.



NCSE staff. From left to right: Eric Meikle, Emily Cheng, Glenn Branch, Meche Aguirre, Molleen Matsumura, Eugenie C Scott. Not pictured: Philip Spieth, Tully Weberg. Photograph: John R Cole.

Three New Faces at NCSE

It was not so long ago that my name appeared under a similar headline (*see* RNCSE *1999; 19 [5]: 13*). And now I get to announce 3 new colleagues, all of whom are working hard in their various ways to resist the encroachments of creationism.

Mercedes "Meche" Aguirre is the new secretary/receptionist. Her responsibilities include taking care of new memberships, renewals, and donations, helping with information requests, and making sure that the day-to-day work of the NCSE office proceeds smoothly. And she is doing a wonderful job! She is a graduate of Mills College in Oakland, California.

Emily Cheng is our archivist, funded by a grant from the Deer Creek Foundation. Her task is to sort through and bring order to NCSE's extensive records — audio, video, and print — related to creationism. There are probably few people who have listened to and viewed as many creationist programs as she has! She is a graduate of the University of California at Berkeley, where she majored in geology, and she plans to attend graduate school in literature next year.

Philip T Spieth, whom constant readers will remember from his essay–review of Michael Denton's *Nature's Destiny* (*see* RNCSE *1998; 18 [2]: 10–14*), is the new Director of Operations for NCSE. Working behind the scenes, he is helping to update and manage NCSE's accounting system and to relieve Genie Scott of administrative tasks that take time away from her "front line" duties. He is working part-time for NCSE while he is winding down a 30-year career as a professor of genetics at the University of California at Berkeley.

Please join us in welcoming all 3 new valued staff members aboard!

Our New Web Site

At last, the new NCSE web site is up and running! Frequent surfers of the World Wide Web will have noticed that a beautiful new web site has replaced the old one (which one member once jokingly referred to as "that text file you call a web site"). Among other improvements, the new web site offers visitors the chance to join NCSE on-line through a secure credit card server.

Our deepest thanks go to NCSE member Ira Walters, who volunteered a truly amazing amount of his time and skill in developing the new web site. With the advent of the World Wide Web, it is crucial for an organization such as ours to have a professional and polished presence on the Web. In 1999, NCSE's web site averaged over 800 hits per day, and the statistics for 2000 are even higher. Every user of our web site — whether student, teacher, scientist, concerned citizen, or curious onlooker — who finds it easy to navigate and clearer to understand will owe Ira a debt of gratitude.

The new web site is accessible at *two* addresses: <http://www.natcenscied.org> and our new, easier-to-remember (and type) address, <http://www.ncseweb.org>. Similarly, e-mail may be addressed to either domain name; for example, e-mail to NCSE may be addressed either to ncse@natcenscied.org or to ncse@ncseweb.org. Please do update your bookmarks and address books, however, because we plan to phase out natcenscied.org in favor of ncseweb.org. In the rest of this issue of *RNCSE*, you will see that we are now using it exclusively.

NCSE Paleontology/Geology Field Trip

April 27 & 28, 2001 GREATER PITTSBURGH & THE ALLEGHENY RIVER

NCSE members and friends are invited to spend an exciting 2 days studying the geology and paleontology of greater Pittsburgh, Pennsylvania. This special 2-day program is led by NCSE member Albert Kollar, a staff member at the Carnegie Museum of Natural History in Pittsburgh.

ITINERARY

Friday, April 27, 2001
Morning — Participate in program on the geology and paleontology of the region held at the Carnegie Museum. Lunch on your own.
Afternoon — Special guided tour of museum, exhibits, and behind the scene collections.

Saturday, April 28, 2001
Field trip aboard the science ship, *The Voyager*: 10-mile cruise on the Allegheny River exploring its geography, geology, and topography. View the effects of the last ice age on the region. Special on-board program while exploring river locks.
Box lunch available.
Return to the Carnegie Science Center for wrap-up.

RESERVE NOW! SPACE IS LIMITED!

Cost: $80 per person for 2-day program
$70 for NCSE members
$10 per person for box lunch on April 28.

Send your nonrefundable deposit of $25 per person to:
Andrew J Petto, NCSE Paleontology Field Trip
Division of Liberal Arts, University of the Arts
320 S Broad Street • Philadelphia PA 19102-4994

Payment in full due on or before March 30, 2001.

Number of people reserving _____ Number of box lunches _____ Total Amount Due _____

Name _____

Address _____

City _____ State _____ Zip _____

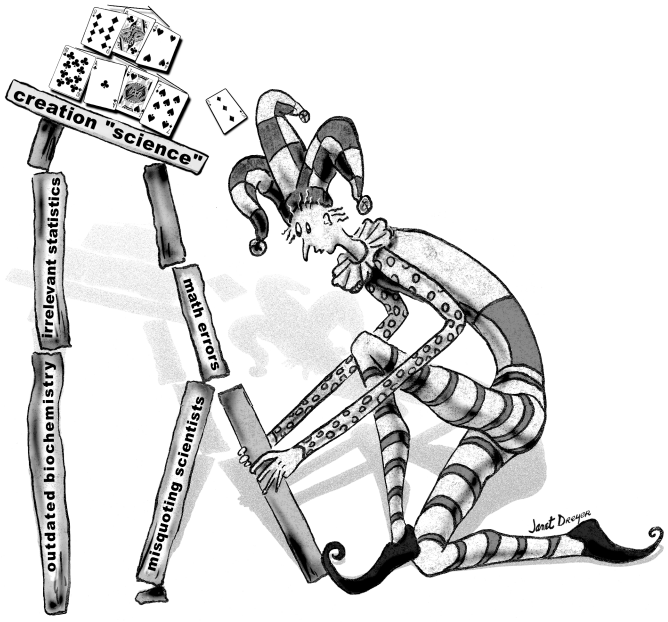
e-mail _____ Telephone ( ) _____ Fax ( ) _____

☐ Check (US dollars) ☐ Charge to: ☐ VISA ☐ Master Card

Credit card number _____ Exp. Date _____

Name as it appears on card _____ Signature _____

To learn more, call Andrew Petto at (215) 717-6276, or e-mail trip@ncseweb.org.



Creationism and Pseudomathematics

Thomas Robson

We are well aware of anti-evolutionists' fondness for presenting their audiences with numbers of dizzying magnitude that they use to represent incredibly low probabilities for such events as the chance formation of a protein molecule, the origin of life, and the like. Thus they argue that it is irrational to believe that the event in question could have happened naturally (they mean "by chance") without the aid of intelligent design. In some cases, such as the chance formation of habitable planets, one may avoid a technical discussion of the physical processes involved and respond simply by pointing out that the universe is a very big place, containing countless galaxies, stars, and planetary systems, thus providing so much opportunity for the natural occurrence of the event in question that the probability may be quite high that such an event would occur *somewhere*. Furthermore, if the universe is infinite, providing the event with infinitely many chances to occur, then the occurrence of the event is a virtual certainty. Thus creationist probability arguments can often be undermined by pointing out that any event with a probability greater than 0, no matter how low, will be likely to happen if given enough opportunity, and sure to happen if opportunity is unlimited.

This principle is sometimes illustrated with the following thought experiment (of which the reader has probably heard one version or another): Suppose that a monkey, trained to hit the keys of a typewriter one by one in a *truly random fashion*, types forever, producing infinitely many pages of text. No one doubts that the monkey would type page after page of gibberish, but it follows from the above principle that sooner or later the monkey would type all of the works of Shakespeare from beginning to end, without error, solely by accident.

Unfortunately, this result of the thought experiment, and thus the principle itself, is sometimes explicitly rejected by creationists. One way of trying to justify their denial of this principle is by an appeal to what creationists refer to as Borel's single law of chance — a claim made by the French probability theorist Emile Borel. According to creationists, Borel's single law of chance says that any event with a probability lower than 1 in 10^{50} is so improbable as to be impossible (Kennedy 1980: 57; Ankerberg and Weldon 1998: 183; Harber 1998: 33; Mastropaolo 1999: iii). The implication is that, since the origin of life, the evolution of humans, and many other events may have a probability below this limit, they could not possibly have happened by chance no matter how much opportunity there may have been for them to occur.

Thus creationists attempt to protect their probability arguments from our sufficient opportunity principle by invoking this single beloved mathematical law. Borel did in fact propose such a law. However, just as creationists have misrepresented the second law of thermodynamics, so have they misrepresented Borel's law of chance. So what did Borel really mean? Here is an illustration.

LIGHTNING STRIKES — OFTEN!

Hardly any of us really worries about getting struck by lightning. The probability that any individual will ever be struck by lightning is extremely low. But with so many people in the world, there is ample opportunity for this rare event to happen from time to time. It would be amazing if it *never* happened; and indeed many of us do know of such an event. Thus there are some highly improbable events that may be rationally expected to happen occasionally.

Thomas Robson has degrees in mathematics and philosophy, and is trained in mathematics education. He currently teaches philosophy at Labette Community College in Parsons, Kansas.

On the other hand, we can imagine other events (such as a monkey's accidentally typing Shakespeare) that are so improbable that the entire observable universe cannot provide enough opportunity for us rationally to expect the event in question to occur. Any event of this sort that has *any* probability at all is still possible — it is just that it would be foolish to bet on its occurrence, not only at a particular place or time, but anywhere ever (within the spatial and temporal confines of the observable universe). Borel said that such events, having a probability of no more than roughly 1 in 10^{50}, never occur (Borel 1965: 57). But this law of chance is not *literally* true, for, as we shall see, such events can and do happen. I think that a more accurate way to say what Borel had in mind is that *in reality*, no such event can *be rationally predicted* ever to occur.

Unfortunately, because, I suspect, of the carelessness of creationists' research, they have failed to grasp Borel's intent and instead have taken his claim at face value — as saying literally that events of such low probabilities cannot possibly occur! For example, according to Scott Huse, "[M]athematicians generally consider any event with a probability of less than 1 chance in 10^{50} as having a zero probability ([that is] it is impossible)" (Huse 1997: 123). So in effect we are told that, according to Borel's single law of chance, even if the observable universe did provide unlimited opportunity for their occurrence, such events are just too improbable ever to occur (Ankerberg and Weldon 1998: 329–30). It is this claim with which I take issue (as would Borel), for though one need not be learned in mathematics to find the claim questionable, many laypeople, I fear, may find it all too easy to believe.

All Nonzero Probabilities Are Possible

The probability of an event is expressed as a real number from 0 to 1; the more probable the event, the higher the number. An event can have only one probability at any time, just as a person at any given time can have only one age. However, anti-evolutionists misconstrue Borel's law of chance to imply the absurdity that low-probability events are assigned 2 different probabilities — their *true* probability and a probability of 0.

By way of example, suppose that one were to program a computer to generate 100 random digits. There would be 10^{100} equally likely possible outcomes. The probability of any given outcome would thus be 10^{-100}. Applying the creationist "law of chance", we would have to conclude that any conceivable outcome, because it has a probability less than 10^{-50}, is literally impossible, having no chance of occurring and thus having a probability of 0 (see the Huse quote above). But clearly no event can have a probability of 10^{-100} *and* a probability of 0 (unless we think that $1/10^{100} = 0$, which is as false as the claim that $2 + 2 = 5$). Moreover, since the conceivable outcomes are what mathematicians call mutually exclusive and jointly exhaustive, the sum of all their individual probabilities must equal 1, which they cannot do if they are all 0.

Fortunately, one need only carry out this experiment to see the anti-evolutionists' version of this "law of chance" falsified. For surely *some* outcome must be produced when we instruct the computer to select 100 random digits, and that outcome will have a probability of 10^{-100} — far below the supposed threshold of possibility. (Borel, on the other hand, would say that no *preconceived* outcome could be rationally expected to occur, because the probability of successfully guessing the outcome in advance is too low for it to be expected to happen in the real world.) Thus we see that the anti-evolutionist appeal to Borel's law of chance fails to refute the principle that any event with a positive probability, no matter how small, is bound to happen somewhere sometime if given infinitely many chances.

Typing Monkeys and the Classics

Another way that anti-evolutionists try to get around this principle is simply by a dubious appeal to common sense. As one apologist argues, "It does not matter how much time we give nature; the large numerical odds simply are irrelevant: we must simply admit that no matter how much time and how much luck, evolution could not have happened" (Lutzer 1998: 159). Unfortunately, common sense is not always, and certainly not in this case, a reliable guide to mathematical truth.

For example, Patrick Glynn, in *God: The Evidence*, criticizes our thought experiment about the endlessly typing monkey in this way:

> [I]t does not matter if there is an infinity of days. … It is a gross fallacy to suppose that the quantity of days or time available changes anything. (To put the proposition mathematically, the probability on any given day that the monkey will type the works of Shakespeare . . . is not one in some very, very large number; it is zero.) Randomness does not engender order on any appreciable scale, no matter how many billions of years or opportunities you give it (Glynn 1997: 46).

But instead of relying on gut instinct, let us see if a far more reliable appeal to probability theory cannot shed some light on the subject. (Borel's law of chance is of no use to us here, for it is applicable only to real world cases, not hypothetical cases like this where we have eternity at our disposal.)

Let us say that Shakespeare's *Hamlet* is x typed pages long, y is the number of characters that can fit on a page, and z is the number of characters on a typewriter. Thus a text x pages long contains xy characters, each of which could be any one of z possibilities. There are then z^{xy} possible ways of ran-

domly typing x pages of text, all of which are equally likely and exactly one of which is *Hamlet*. Now suppose that we divide the monkey's work into trials, the first trial consisting of the first x pages typed, the second trial consisting of the second x pages, and so on. Since the monkey will ultimately type infinitely many pages, he will ultimately type infinitely many trials. Each trial is an opportunity for the monkey to type *Hamlet*. (I am, of course, ignoring the possibility that the monkey might begin typing *Hamlet* midway through one trial and finish it midway through the next.)

On any given trial, the probability that the monkey will type *Hamlet* is $\mathbf{1}/z^{xy}$, which we shall call p. And on any given trial, the probability that the monkey will *fail* to type *Hamlet* is **1**–p, which we shall call q. Thus the probability of failure is q for the first trial, q for the second trial, q for the third trial, and so on. Consider now the probability of failure on the first 2 trials, which is q^2, and the probability of failure on the first 3 trials, which is q^3, and so on. We thus see that the probability of failure on all of the first *n* trials is q^n. What then is the probability that the monkey will fail on *all* the trials, that he will *never* type *Hamlet*? Since there are infinitely many trials, the probability could be expressed as q raised to the power of infinity.

The opponents of evolution are not interested in good science ... neither are they interested in good mathematics.

But what are we to make of this? Since z^{xy} is a finite positive number, $\mathbf{1}/z^{xy}$ (the probability on any trial that the monkey will type *Hamlet*) must be greater than 0. And $p = \mathbf{1}/z^{xy}$, so $p > \mathbf{0}$. Since $p > \mathbf{0}$, we know that **1**–p is smaller than 1. And since **1**–p = q, it follows that q must be smaller than 1. Thus we see that q, the probability on any given trial that the monkey will fail to type *Hamlet*, must be a real number greater than 0 and less than 1. Now if we pick any number on the number line greater than 0 and less than 1 (q is such a number) and multiply it by itself many times, thus raising it to higher and higher powers, the product will approach 0; the higher the power, the closer to 0 the product will be. If the power is infinite, the ultimate result, in the end, is 0. Therefore, q to the power of infinity is 0.

Now recall that q to the power of infinity is the probability that the monkey would *never* type *Hamlet*. And we have just seen that this probability is 0. This means that there is a probability of 1, or 100%, that the monkey *will* type *Hamlet* at least once over the course of eternity. It would be a miracle if he did not! The same goes for every other work of Shakespeare, as well as the Bible, *War and Peace*, this article, your personal diary, anything imaginable (of finite length) — you name it, the monkey will eventually type it.

In fact, this principle is not limited to this thought experiment about the typing monkeys, but is applicable to any improbable event whatsoever. Provided it has a constant positive probability (to be represented by p), the event in question is certain to happen if given unlimited opportunity. Any attempt to deny this, whether based on Borel's law of chance, common horse sense, or anything else, is misguided.

The Heart of the Matter

Anti-evolutionists, of course, will continue to employ their probability arguments against the natural formation of proteins, cells, and the like, despite everything said in this article. There are 2 reasons for this. First, in all fairness, their probability arguments often cannot be adequately refuted without a highly technical scientific explanation of the physical processes involved in the "improbable" event in question, and no such discussion was attempted here for the same reason that none is often attempted in public discussions of the issues.

Second, and more importantly, even if all the scientific matters had been discussed, it would make no difference. The opponents of evolution are not interested in good science, and as I have attempted to show in this article, neither are they interested in good mathematics. Hence their arguments are not based on a complete and contemporary understanding of the scientific and mathematical principles that are relevant to the issue. This is yet another reason why creationist material has no business being taught in science classes — it threatens our students' education not only with bad science, but also bad mathematics.

References

Ankerberg J, Weldon J. *Darwin's Leap of Faith*. Eugene (OR): Harvest House Publishers, 1998.

Borel E. *Elements of the Theory of Probability*. Englewood Cliffs (NJ): Prentice-Hall, Inc., 1965.

Glynn P. *God: The Evidence: The Reconciliation of Faith and Reason in a Postsecular World*. Rocklin (CA): Prima Publishing, 1997.

Harber F. *Reasons for Believing: A Seeker's Guide to Christianity*. Green Forest (AR): New Leaf Press, 1998.

Huse SM. *The Collapse of Evolution*. 3rd ed. Grand Rapids (MI): Baker Books, 1997.

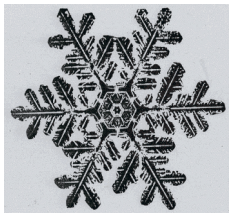
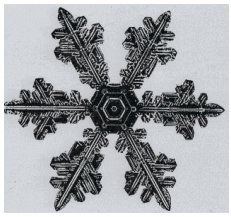
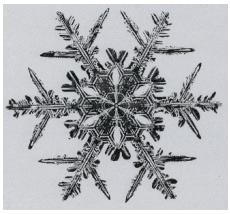
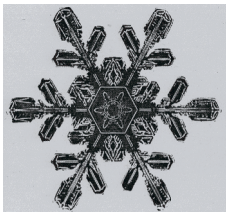
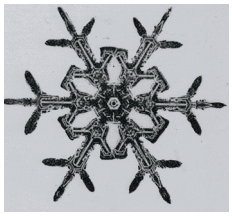
Kennedy DJ. *Why I Believe*. Dallas (TX): Word Publishing, 1980.

Lutzer EW. *Seven Reasons Why You Can Trust the Bible*. Chicago: Moody Press, 1998.

Mastropaolo J. Evolution is biologically impossible. *Impact* 1999 Nov; 317.

Author's Address

Thomas Robson
Royal Orleans, 3902 College View Drive #8D
Joplin MO 64801
twrobson@hotmail.com

Evolution and Probability

David H Bailey

Some of the most impressive-sounding criticisms of the conventional theory of biological evolution involve probability. Such arguments have been raised, not just by religious fundamentalists, but by numerous others who are reluctant to accept the prevailing scientific theory of the history of life on earth. On the basis of such arguments, some conclude that the currently accepted theories of naturalistic origin of life and evolution are seriously flawed. Others argue further that these arguments demonstrate that life on earth could only be the result of miraculous acts by a divine creator.

As a scientist of religious faith with training in probability theory, I have studied a number of these arguments in some detail. It is well known among mathematicians that probability arguments are treacherous — even experts can fool themselves. In the hands of those who are not expert both in probability *and* evolution, and especially in the hands of someone with an agenda to advance, the results are, in my experience, almost universally invalid.

A few examples will illustrate how probability should and should not be used.

Looking at Hemoglobin

Anti-evolutionists have for many years advanced probability arguments in their efforts to "prove" the impossibility of scientific models in cosmology, astronomy, physics, and the origin of life. More recently, Michael Behe's concept of "irreducible complexity" in biochemical systems has fueled various arguments about the impossibility of a natural emergence of complex biological systems, such as blood clotting cascades, the bacterial flagellum, and hemoglobin. The basic approach used in these studies is to calculate the probability that some phenomenon could occur by a natural means, and then to claim that the extremely remote probabilities render the existing scientific theory invalid.

David Foster's *The Philosophical Scientists* (1993) uses such an approach, derived loosely from the earlier work of Hoyle and Wickramasinghe (1981; *see related article by Richard Carrier on p 25*). The general argument goes something like this:

> Consider the alpha chain of human hemoglobin — a key component of blood that serves as a transfer agent for oxygen. The alpha hemoglobin molecule is a protein chain based on a sequence of 141 amino acids, and the hemoglobin of virtually every human has the same sequence.
>
> There are 20 different amino acids common in living systems. Thus the number of different chains [141 amino acids long] is 20^{141}, or roughly 10^{183}. If 5 billion years ago, as many as 10^{40} amino-acid–molecule generators, each producing a different randomly chosen 141–amino-acid sequence one billion times per second, began generating sequences, then at the present point in time only about 10^{66} sequences would have been generated. Thus the probability that human alpha hemoglobin would have been produced is about $10^{66} \div 10^{183} = 10^{-117}$, a fantastically small number. Thus no conventional theory of molecular evolution can account for the origin of human alpha hemoglobin.

This is an intriguing line of reasoning, but it has serious flaws. One flaw, common to many arguments of this sort, is that it is an after-the-fact assessment of probability, which is unreliable without a very careful consideration of all possible alternate contingencies. This difficulty can be illustrated by examining discrepancy counts between the alpha hemoglobin chains of humans and other animal species (see the examples in Hoyle and Wickramasinghe 1981: 17).

As one might expect from evolutionary models, the differences in the molecular structures of these hemoglobin chains are entirely consistent with the phylogenetic "family tree". In particular, the human alpha chain is identical with that of chimpanzees and differs by only 1 amino acid from that of gorillas. In more distant vertebrate relatives, the alpha hemoglobin chain differs more: by 25 amino acids between humans and rabbits and by about 100 between humans and various fish species.

Thus there are countless variants of the alpha hemoglobin chain that perform the essential function of oxygen transport, since these variants successfully serve that function in various other animal species. Indeed, most of the 141 amino acids can be changed without altering this basic oxygen transport function. The process of evolution long ago settled on one particular sequence for humans, but many others *might* have been selected without loss of essential function.

Revising the probability calculations used by Hoyle and Wickramasinghe from this point of view — that only about *25* particular locations must be correct to enable the oxygen transport function — the probability that a chain 141 amino acids long would be a usable hemoglobin molecule can be calculated as 1 in 20^{25}, or roughly 1 in 10^{33}. This is still a very small probability, but it is vastly greater than 1 in 10^{183} — the probability calculated above. Given odds of 1 in 10^{33}, the hypothetical random molecular generators mentioned above could discover a usable hemoglobin molecule trillions of times per second (although no one suggests this is the way that hemoglobin actually arose). Furthermore, the probability calculations employed by anti-evolutionists assume that all 10^{183} amino acid chains of length 141 are equally likely to be produced. Instead, we know that some classes of molecules are much more likely than others to arise naturally.

Modern biology has only a partial idea of the process through which human hemoglobin originated and how it has changed through the years. Thus it is highly premature to pretend that anyone understands the process well enough to compute accurate probabilities. Such calculations are inconclusive.

Learning From Snowflakes

Another way to understand better the difficulties with anti-evolution probability arguments is to consider snowflakes. Each individual flake is much less than a milligram in mass, yet snowflakes exhibit remarkably beautiful and symmetrical patterns. Bentley and Humphrey's book *Snow Crystals* (1962) includes over 2000 high-resolution black-and-white photos of real snowflakes. Many of these images are utterly fantastic, with wildly improbable yet astonishingly regular patterns. Each one occurred naturally and was collected and photographed by Bentley and his assistants.

What are the chances that one of these structures can form "at random"? To simplify the problem, let us consider only the phenomenon of 6-way symmetry, a characteristic of almost all snowflakes. Imagine laying out the snowflake on a small grid with 100 subdivisions on a side (so that the grid contains 10 000 cells) divided into 6 equal sectors (with about 1666 cells each). We can calculate the probability that the pattern in one sector will be identical with the 5 patterns in other sectors as follows: the probability that 2 sectors have identical patterns is approximately 2^{-1666}, or roughly 10^{-500}; this value raised to the 5th power is 10^{-2500}. This probability is even more extreme that those I have seen in anti-evolution literature.

Even if we allow that snowflakes in nature are not perfectly symmetrical (so that perhaps some stretching might be required for the sectors to match precisely), a snowflake is an exceedingly improbable structure by this reckoning. In particular, it is extremely unlikely that a random roll-of-the-dice assemblage of water molecules would constitute a single snowflake with a specific designated structure. And yet this phenomenon is repeated trillions of times in a typical snowstorm.

It is important to note that, in contrast to evolution, this process does not require billions of years to occur — most snowstorms last only between a few minutes to hours at most. Further, there is no coding mechanism to specify the outcome, as there is in the intricate machinery of DNA-based genetics. Snowflakes just happen — a homogeneous, undifferentiated mass of water molecules cools and becomes a sea of beautiful snowflakes with highly specific and differentiated structures. One could almost convince oneself that snowflakes constitute a demonstration of supernatural power.

What is wrong with the above line of reasoning? It is the fundamental assumption that a snowflake forms all at once as a random roll-of-the-dice conglomeration of water molecules. It does not. It is the product of a long series of aggregations, each acting under known physical laws of atomic interactions, forming by building on pre-existing structures much as a crystal of salt forms.

Arguing from Probability and Design

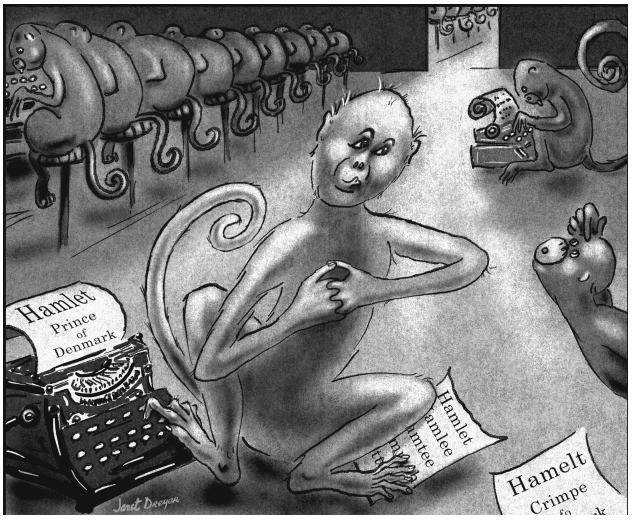
This same general criticism applies to many probability-based arguments against evolution. Such arguments usually assume an all-at-once, completely random assemblage with no pre-existing structure. But this is most assuredly not what has happened — the organism or amino-acid chain we see today is the end product of countless generations over many millions of years, taking a small step each time. At each step, the existing structure is modified — added to, subtracted from, and so on. It is not "back to the drawing board" each time, but rather adjusting, fine-tuning, retooling existing plans. The evolutionary process is astonishing — one that we do not yet fully understand — but there is clearly nothing there that represents a violation of any of the fundamental laws of probability.

Probability calculations in biology should be a tool to help us calibrate the diversity of life and the extent to which various lineages may have diverged from common ancestors. Instead, they often are used as a tool to manipulate scientifically unsophisticated audiences. Further, probability-based arguments for a Creator are, as far as I can tell, merely another instance of the "God of the gaps" approach — the shopworn philosophy that God is to be found in the gaps of what currently remains unexplained in science. Those who have adopted this approach over the centuries have invariably been disappointed as scientific knowledge fills more and more of the remaining "gaps".

Nowadays the catchphrase for this approach is "Intelligent Design" (ID). The idea is that such remote

Are the Odds Against the Origin of Life Too Great?

Richard Carrier



Introduction

All too frequently anti-evolutionists offer statistical arguments to "prove" that the odds against the natural origin of life are so great that we must posit a Creator to explain the event. David Foster, for example, in his book *The Philosophical Scientists* (1993), uses two specific examples as proof of the impossibility of life — the odds against the spontaneous assembly of the genome of the T4 bacteriophage, and the odds against the spontaneous assembly of the human hemoglobin molecule. Of course, no scientist actually proposes that either the T4 genome or hemoglobin was originally assembled spontaneously in its present form.

I have encountered many such arguments, and since they are always obscure and often antiquated, it is rarely easy to ascertain how they were derived and whether they have any merit. Since it is helpful to have a summary analysis of the most common examples, this essay examines these claims in order to provide a primer for *RNCSE* readers so that they can recognize and respond to them whenever they arise in conversations, debates, books, or articles. (Ian Musgrave's on-line essay complements my work here; see <http://www-personal.monash.edu.au/~ianm/prob.htm>). In this essay, I will deal first with scientific work misused by anti-evolutionists and then with the pseudoscientific assertions of the anti-evolutionists themselves.

Richard Carrier is a doctoral candidate in ancient history at Columbia University in New York with a specialization in the history of science.

Scientific Work Misused by Anti-evolutionists

In the course of setting up and testing hypotheses, scientists often calculate probabilities to measure the likelihood of events or phenomena in the models and theories that they are studying. In work on the origin of life, some of these calculations estimate the likelihood that certain types of molecules could arise by natural processes on earth. The calculations that are often extracted and misused by anti-evolutionists are described in this section.

Frank Salisbury

One of the few serious scientific attempts at such calculations is found in the often-cited and vastly out-of-date article "Natural selection and the complexity of the gene" by Frank Salisbury (1969). The purpose of this article was to identify a scientific problem and suggest possible avenues of research toward its solution — an approach rarely seen in anti-evolutionist literature. The article helpfully cites all previous scientific literature on this issue (I have not found an equivalent work summing the literature up to any more recent date).

Salisbury's basic assumptions and their limitations are clearly stated. First, he calculates that the odds of life's beginning in the known expanse and age of the universe are 1 in 10^{415}, but, as he says himself, this is only true "if only one DNA molecule [1000 nucleotides long] were suitable" to get biology going. In other words, if other 1000–nucleotide-long molecules could be substituted, or if shorter molecules would do, then these odds change for the better. Salisbury himself

improbabilities can be overcome only by a designer. Many in the ID movement see that designer as the God of the Bible, and design in nature as proof of the existence and direct involvement of God in minute details of everyday life. But it is wise to keep in mind the common experience of many religious believers, who have found that seeking "proofs" for the existence of God (scientific or otherwise) is an ineffective and often counterproductive route to faith. Jesus of Nazareth frequently commented on the dangers of seeking "signs" (Matthew 12:39, 16:4; Mark 8:12; Luke 11:29). Sounds like good advice to me.

References

Bentley WA, Humphreys WJ. *Snow Crystals*. NY: Dover Publications, 1962.

Foster D. *The Philosophical Scientists*. New York: Barnes & Noble Books, 1993.

Hoyle F, Wickramasinghe C. *Evolution from Space.* London: JM Dent and Sons, 1981.

Author's address:

David H Bailey
Lawrence Berkeley National Laboratory
Berkeley CA 94720
dhbailey@lbl.gov

notes that the odds are good that at least one replicator 141 nucleotides long or shorter could have formed, given the age and expanse of the universe as then estimated. The discovery of the RNA-precursor in *tetrahymena* research (see Shapiro 1988: 71) may render Salisbury's concerns moot; very small, simple replicators are now known to be possible.

Another often-abused article by Salisbury appeared in *American Biology Teacher* (Salisbury 1971). In this article, Salisbury calculates the number of possible arrangements of nucleotides in a "medium protein" 300 amino acids long, arriving at 10^{600}. The most important point is that Salisbury does not argue that this proves that a natural origin of life is too improbable. On the contrary, several assumptions that he uses in his calculation invalidate the use of this result for that purpose. First, to model the conditions for the first life, we want to examine the *minimum* self-replicating protein. Second, Salisbury's calculation only gives us the number of different arrangements; billions upon billions — not just one — of those arrangements *could*, for all we know, be viable self-replicators. Third, he assumes a 4-nucleotide DNA code, which represents the condition for life *on earth*, but there is no *a priori* reason that life had to be coded that way: alien life may exist based on 4 different nucleotides, or on a different number of nucleotides, and so on. So these calculations assume that ours is the only possible system of DNA coding. Fourth, all that is needed to get life going is anything that replicates, and 4-bit–coded DNA is not the only feasible molecule that might do that — a much simpler RNA molecule could have been the starting point. Therefore, the assertion that there are 10^{600} combinations of nucleotides of which only one can successfully self-replicate presupposes that the odds against life's forming by natural processes are more remote than they really are.

[A]ll that is needed to get life going is anything that replicates, and 4-bit–coded DNA is not the only feasible molecule.

It is important to note that Salisbury also wrote *The Creation* (1976). McIver (1992: 240) reviews this work and Salisbury's conclusions on various scenarios of origins and concludes that Salisbury favorably discussed arguments presented in the books and pamphlets of the Institute for Creation Research (ICR). These materials are in contrast to the papers in *Nature* (Salisbury 1969) and in *American Biology Teacher* (1971), and it remains unclear to what extent Salisbury was swayed by the arguments from the ICR in his interpretation of the implications of his statistical studies.

Henry Quastler

Both Salisbury and James Coppedge (see below) cite Henry Quastler's work, which actually *supports* the possibility of a natural origin of life (Quastler 1964). Quastler's approach is unique: he calculates the information content of a DNA code. He first argues that "a low estimate of the information content of a bacterium" is "10^3 bits ... [which] corresponds to ... a single choice among 2^{1000} possibilities." This means that "the probability of making such a choice by accident is 10^{-301}" (1964: 4). After estimating the available time, materials, and so on, he concludes that "the probability of life['s] having originated through random choice...[is] about 10^{-255}" (1964: 6). Of course, Quastler knows very well that life did not begin with a bacterium, and so he does not say that these are the odds against the origin of life. Rather, he claims that his calculations show that the earliest life must have been simpler and that natural selection can build up the information content of this complex bacterium beginning with something smaller.

When Quastler considers numerous other aspects of a possible original replicator, his calculation of even the least likely chance of life's beginning naturally is 10^{-20}, which is well within the realm of the possible — Borel (1962), for example, calculates that any event with a probability greater than 10^{-50} could have happened at least once given the age and expanse of the cosmos. Quastler concludes that this "suggests that the probability of obtaining a complete set of enzymes by coding proteins from 10^7 nucleotide pairs may be quite high" (1964: 46). In other words, it is quite possible for this to occur naturally. After considering additional features and characteristics, Quastler calculates a probability between 10^{-6} and 10^{-30} (1964: 58). Even under the conditions imposed by Borel, Quastler's work proves that the natural origin of life is not excessively improbable at all. Anti-evolutionists typically omit this part of his work and erroneously quote only his initial calculations, which even *he* declares to be the incorrect solution.

Hubert Yockey

Another scholarly source is Hubert Yockey's article "Self organization origin of life scenarios and information theory" in the *Journal of Theoretical Biology* (1981) — an extension of work he published earlier in the same journal (Yockey 1977). This paper argues that *alien* life is so improbable that the scientific effort devoted to the Search for Extra-Terrestrial Intelligence should be focused on "research on the origin of life" on earth. Although he does not generate any actual estimates of probability, they can be extracted from the calculations he presents. Yockey argues that only 10^5 arrangements of a protein 100 amino acids long, from among 1.26×10^{130} possible arrangements, are of concern to biology, if we assume a 4-bit code. On this basis, we can calculate from this position that the odds against life's starting based on such a protein are 1 in 10^{125}. It is important to note that this is *not* Yockey's argument, although anti-evolutionists have tried to spin it that way.

There are 2 problems with this interpretation, however. First, Yockey assumes that only the 20 amino acids found in organisms on earth are relevant, but as far as we know, life might be possible with any combination of any number of the thousands of varieties that can exist in nature. The mere fact that life on our planet settled on a certain 20 does not mean that this is the only way it might have formed. Yockey also assumes that only chains with exactly 100 amino acids are relevant, but life could have been begun by chains of many different lengths. Yockey does not include in his calculations all the relevant combinations of all the naturally occurring chain lengths that might be self-replicating; he only solves for the case of the 100–amino-acid chain.

Yockey also generates another value that is misrepresented by anti-evolutionists. Assuming the maximum estimate of suitable planets in the universe, all the known amino acids, the known age of the universe, and a recombination rate of twice per day (on average), he

tells us that 1.61×10^{60} different chains 100 amino acids long will be produced. Because Yockey does not estimate how many of those combinations would be viable (probably more than 1), there is no way to use this value to estimate the odds against life's originating naturally. Nevertheless, this value is so used by Bradley and Thaxton (1994), who fail to explain the context or the assumptions that give the estimate meaning.

Of course, even Yockey's other assumptions are also problematic. For example, he agrees that a replicating protein chain as large as 100 000 amino acids long could form, given the known age and expanse of the universe, if we assume a protogene with fewer than the current 4 nucleotide bases (1981: 22). He argues against the possibility of such a replicating system, however, on the grounds that such a small code would require longer chains to accomplish the same results as a shorter chain based on the current 4-base system. But that consideration is irrelevant, because all that is needed to get life going is anything that replicates — no matter how inefficiently or inaccurately. Simply put, the successful replicators will persist and continue to reproduce, while the failures will not, no matter how many more there are. Then natural selection can go to work. And it is possible to imagine how a 2-bit replicator could chain with another in a symbiotic relationship, thereby giving rise to a 4-bit code like our present DNA system. Yockey's work does not evaluate such a scenario.

Yockey's book *Information Theory and Molecular Biology* (1992) repeats the same arguments. Among other things, he claims that "perhaps 300 to 400 amino acids" are required for the simplest replicator, although he admits that it may be as few as 56, something few others are willing to acknowledge. When he calculates the probability of a single protein's forming by chance (cytochrome c), his result is 2×10^{-44} (1992: 254–7). This probability is low, but within the threshold set by Borel (1962) that any event with odds better than 1 in 10^{50} could have happened at least once in all of time and space. But this calculation is irrelevant, since we need to know the chance of *any* viable replicating protein's arising, not just one *specific* protein. Yockey's approach is like arguing that a specific individual is most unlikely to win the lottery and therefore the lottery can never be won, when in fact on a regular basis *someone* wins the lottery. What we want to know are the odds of some protein's winning the lottery, not the odds of a specific protein's doing so. To make matters worse, Yockey increases his estimate to 2.3×10^{-75} on the grounds that chirality (the bias of living things for only left-handed proteins) must have happened by chance, although he acknowledges that it may have happened deterministically. If there is a deterministic process for selected left-handed forms of proteins in living things, then the larger estimate — based as it is on the assumption of random chirality — is both irrelevant and misleading.

Carl Sagan

Anti-evolutionists also cite a panel presentation given by Carl Sagan at a conference on the search for extraterrestrial intelligence (SETI). In this paper, Sagan estimates the odds against the chance assembly of a *specific* human genome — in other words, the genome of a specific person, and not just *any* human — as 1 in $10^{2\,000\,000\,000}$ (Sagan and others 1973: 45–6). He reaches these odds by noting that a simple protein "might consist" of 100 amino acids (for each of which there are 20 "biological varieties"); the chance of random assembly, for one specific protein of this sort, is 1 in 10^{130}. He uses these statistics as a rhetorical foil for the assertions that no human genome is assembled at random and that life did not have to start with only one possible protein of a specific type. Instead, he argues that "the preferential replication, the preferential reproduction of organisms, through the natural selection of small mutations, acts as a kind of probability sieve, a probability selector", so that one must account for natural selection in estimating the odds of any alien species' existing elsewhere in the universe, and not just calculate the odds of random assembly as in the examples he used. Nevertheless, Sagan's words are used contrary to his intentions by anti-evolutionists such as Clifford Wilson and John Weldon who grab at the numbers without paying attention to their context.

Julian Huxley

One of the most remarkable misquotations, which takes the gold medal for best example of an abused reference, relies on the work of Julian Huxley. One anti-evolutionist responded to my internet postings claiming that Huxley determined that "the odds of the evolution of the horse were 1 in 1000 to the power of 1 000 000." One might immediately wonder how someone who believed this could still be a defender of evolution — after all, if those really were the odds against the *evolution* of the horse, who would accept evolution as a sensible explanation? Of course, Huxley never made such a claim. In fact, he made exactly the *opposite* claim:

> A little calculation demonstrates how incredibly improbable the results of natural selection can be when enough time is available. Following Professor Muller, we can ask what would have been the odds against a higher animal, such as a horse, being produced by chance alone: that is to say by the accidental accumulation of the necessary favorable mutations, without the intervention of selection (1953: 45).

The calculated result is $1 \times 10\,000^{1\,000\,000}$ (1953: 46). It is not important to retrace his method. There are fundamental flaws in his approach, but they do not matter, because he is arguing that, regardless of how high the odds are against *random* accumulation of favorable mutations, the processes that produce complex organisms such as the horse are anything but random. This calculation is for the odds of producing a horse *without* natural selection, and Huxley accordingly sees it as a powerful argument *for* evolution by natural selection. Huxley continues, "thanks to the workings of natural selection and the properties of living substance which make natural selection inevitable", "rare and abnormal events" become "common and normal", and "all objections to a selectionist explanation of evolution that are based on the improbability of its results fall to the ground" (1953: 46–8).

The (Mis)Calculations of Anti-evolutionists

A number of anti-evolutionists have weighed in on the improbability of life's natural emergence. Some of these are "stars" in the creationist firmament, but others are

less well-known. For all of them, the main purpose is to prove that evolution is impossible because life could not have originated by chance or by random natural mechanisms. The argument, of course, is irrelevant, since evolution is indifferent to the way that life originated. Anti-evolutionists have a very difficult time distinguishing evolution, a theory about how complex life arose from simple life, from biogenesis, the theory of how the simplest life came about in the first place. They are not the same. Still, the method and "logic" of these works is worth examining.

James F Coppedge

One of the best examples of the misuse of probability estimates is found in James F Coppedge's *Evolution: Possible or Impossible?* This book nicely shows the typical bizarre pathway between the facts and the conclusions of anti-evolutionists. Coppedge cites an article by Ulric Jelinek in the October 1961 *Campus Challenge* claiming that the odds are 1 in 10^{243} against "2000 atoms" (the size of one particular protein molecule) ending up in precisely that particular order "by accident" (1973: 234). Where did Jelinik get that figure? From Pierre Lecomte du Noüy's book *Human Destiny* (1947: 33–4), which in turn got it from physicist Charles-Eugene Guye. Guye had merely calculated the odds against these atoms' lining up by accident if "a volume" of atoms the size of the earth were "shaken at the speed of light" (quote attributed to Guye without citation by du Noüy). Guye's estimate, of course, ignores all the laws of chemistry, which create preferences for the formation and behavior of molecules, as well as the fact that there are millions if not billions of different possible proteins. Furthermore, because life may have begun from even simpler proteins, this calculation is irrelevant to the issue. It is typical anti-evolutionist fare in that it comes to Coppedge third-hand and is significantly outdated. Not only was the estimate calculated before 1942, but we have learned so much about molecular biology in the last 6 decades — not the least of which is the structure of DNA — that Guye's calculations cannot be salvaged for contemporary use.

Still, Coppedge provides us with one of the most valiant attempts at statistical reasoning among anti-evolutionists. Unlike most others, Coppedge at least attempts to get at the root of the problem by examining the odds of the first theoretically possible organism's arising by chance. But he fails largely because of certain bogus assumptions, which can only partly be blamed on the fact that his work is 25 years out of date. For example, Coppedge says that "the average number of amino acids in proteins of the smallest known living thing is 400, at the very least" (1973: 57). There are two mistakes here. The first is a recurring theme — when discussing the *first* living organism, we should only be concerned with the smallest possible replicating system, not the average-sized. Second, the "smallest known living thing" is already billions of years of evolution removed from the first living thing, having been tested and refined by eons of natural selection.

Coppedge claims that "there is no real reason at present to believe that any living thing has ever existed that is simpler than the…smallest living entity known" (1973: 112). But in truth, there is a very good reason to think otherwise. It is estimated that almost all (over 99%) of the species known to have lived on earth are extinct. Even the "simple" bacteria that we know today are highly evolved from their ancestors (Trevors 1997). Thus we cannot use the characteristics of present life as a basis for calculating the odds of the random formation of the *first* life. The first life must have been far simpler than anything alive today.

Coppedge also makes some specific calculations, and both problems plague his results. For example, he calculates the odds against the origin of life as 1 in 10^{8318}, which he says is "out of all the protein molecules that ever existed on earth, the odds against there being even one set with only left-handed components sufficient for the smallest theoretical living entity" (1973: 76). But his "smallest theoretical living entity" is derived from Harold J Morowitz (1969), who sought to describe the smallest DNA-based genome that can sustain itself, consisting of 239 proteins, with an average of 400 amino acids per protein. His conclusions were largely arbitrary and have since been refuted experimentally (for further details, see the discussion at <http://www.infidels.org/library/modern/richard_carrier/addendaC.html>).

Likewise, the problem of uniform left-handedness has many possible explanations. It is not necessarily a matter of pure chance. Since uniform handedness is important to biological function, it will be selected for. Therefore, even if we are relying entirely on chance to produce handedness in the *first* organism, selection is adequate to explain uniform handedness after that. Furthermore, it is possible that the first living polymers grew on the surface of clays or crystals (Yockey 1981: 18), or in conjunction with "midwife" molecules (Hud and Anet 2000), which would create a natural tendency for all links in the chain to have the same handedness — and these circumstances have other ordering effects that are demonstrably non-random. But most importantly, as even Coppedge knew, "an all–one-handed chain is…more stable" (1973: 249). Consequently, short one-handed chains will last longer than mixed chains, and thus will be more likely to link with more chains and grow, becoming even more stable as the chain gets larger. In other words, only one-handed chains are likely to grow very long naturally. Thus it is no longer a question of random chance, but natural tendency and, again, *natural selection* (for even more on this whole issue, see note 2 in <http://www.infidels.org/library/modern/richard_carrier/addendaB.html>). So this entire discussion — and the calculation that drives it — is now irrelevant.

Coppedge's approach is further flawed by the fact that in his example, he assumes that only one arrangement of proteins and amino acids will work (Morowitz did not claim this), that the 20 amino acids that are currently standardized in earth biology are the only ones that can produce life, and that all 20 are required. However, none of these assumptions is correct — there are billions of bacterial genomes of equal size that are clearly viable, many animals lack one or more of the standard 20 amino acids in their construction, and many more have additional amino acids (humans have 21). His equations also require that an increase in the number of possible amino acids will increase the odds against forming a reliable replicating genome. On the contrary, it should be obvious that if more materials are available, there will be more chances of hitting on

something that works. So his mathematical model is using both the wrong assumptions and the wrong calculations.

In some cases, Coppedge discusses specific proteins. For example, he calculates the odds against proinsulin's forming by chance as 1 in 10^{106} (1973: 102). He assumes, of course, that proinsulin formed spontaneously, although there is no reason to think that it did. Like other anti-evolutionists, he ignores the role that natural selection could play in modifying and enlarging smaller, simpler molecules.

Coppedge then goes on to calculate the odds against "getting [even a single] usable protein" as 1 in 10^{240} in a single step (1973: 104), or as 1 in 10^{161} "in all the history of the earth" (1973: 109). This calculation is based again on the assumption that such a protein must have an average length of 400 amino acids, rather than some minimum possible length (which no one knows). Then he asserts that "the odds against one minimum set of proteins happening in the entire history of the earth are $10^{119\,701}$ to 1" (1973: 111). This estimate is based on all the previous flawed assumptions: the "minimum" 239-protein genome of Morowitz, the 400 amino acids per protein, the assumption that only one combination will work, that all the 20 standard varieties of amino acid are required, that only the 20 standard amino acids are usable, and that only 1 in 10^{240} randomly formed proteins is usable.

Later Coppedge tries to calculate the most favorable odds (1973: 113), by assuming instead that only 10 varieties of amino acids are needed, with only 12 amino acids as a minimum protein size, and 10 proteins as a minimum replicator size. With various other assumptions about chemical quantities and combination rates, he calculates the odds against the formation of a usable protein as 1 in 10^{35} over the entire history of the earth. Of course, this is actually within the realm of cosmic possibility (see above) and so does not disprove the natural origin of life. But his argument is unsound because it assumes that only one arrangement would work (although he allows one meager amino-acid substitution per protein) and that only 10 of the thousands of amino acid possible can work. Indeed, even Coppedge knows that *at least* 20 will work (the number in existence today), so it is clear that his assumption must be false.

Coppedge makes one final calculation — the odds against randomly forming a single gene in a single event are, he figures, 1 in 10^{236}, based on the assumption that a gene requires a chain of at least 1200 amino acids (compare this with Salisbury's assumption of 1000). But to calculate the number of possible combinations that would produce a viable gene, he uses the analogy of the rate of producing a meaningful English word from random letter-combinations — an analogy that works as a metaphor for understanding the process of random generation, but has severe limitations as a model of it. Furthermore, Coppedge overlooks the possibility that genes were not the basis of the *first* life but rather the result of several independent evolutionary modifications to pre-existing self-replicating proteins after living things were established on the earth.

Scientific ignorance leads to the abuse of the scientific literature, and in reading anti-evolutionists' work it is important to pay careful attention to the context in which quoted material originally appeared. Coppedge, for instance, cites Morowitz, who reports (as paraphrased by Coppedge) that "under 'equilibrium' conditions (the stable state reached after initial reactions have balanced), the probability of such a fluctuation during earth's history would be ... 1 chance in $10^{339\,999\,866}$" (1973: 235). In particular, this is "the probability of chance fluctuations that would result in sufficient energy for bond formation" needed to make a living cell. Coppedge's use of this statistic is incompetent because he ignored the context: these are not the odds of the first life's forming, but the odds of enough energy's being available for *any* life to appear at all, in an environment that has reached an effective state of thermal equilibrium — a condition, by the way, that has never obtained on earth. It is obvious that in an *equilibrium* state, with no solar or geothermal energy entering the environment, it would be impossible for life to gather enough energy to emerge. Who needs to calculate the odds against it? Morowitz was demonstrating a fact about chemical systems in environments of maximized entropy, not the unlikelihood of life's originating in a relatively low entropy environment on earth. The fact is that life began in, and has always enjoyed, an active chemical system that is not only far from equilibrium, but receiving steady energy input from the sun and earth. So this statistic has no bearing on the question of the odds of life — Coppedge, and those who depend on his work, are pursuing an irrelevant tangent.

[T]his statistic has no bearing on the question of the odds of life — [its discussion is] an irrelevant tangent.

Fred Hoyle and NC Wickramasinghe

The most commonly cited source for statistical impossibility of the origin of life comes from another odd book, *Evolution From Space*, written by Fred Hoyle and NC Wickramasinghe (1981; published originally by Dent and immediately reprinted by Simon & Schuster that same year, under the title *Evolution From Space: A Theory of Cosmic Creationism*). They calculate the odds against life's naturally forming on earth as 1 in $10^{40\,000}$ (1981: 24). In their calculations, a 20–amino-acid polypeptide must be arranged in precisely the right order for it to fit a corresponding enzyme. The calculation is based on the assumption that the odds against the formation of one corresponding 20–amino-acid enzyme must be multiplied by the number of enzymes currently recognized in living things (2000). The calculation is $(10^{20})^{2000} = 10^{40\,000}$.

There are serious flaws in this calculation. First, they assume that natural selection is equivalent to random shuffling. Second, they assume that 2000 enzymes — all the enzymes used in the whole of biology — have to be produced in the same giant pull of the cosmic slot machine. Third, they assume that early life required complex enzymes working in concert from the outset. As for the first assumption, natural selection is not random, but *selective* — a distinction that is not trivial (a point made by Sagan and others 1973, discussed above). As for the second, Hoyle and Wickramasinghe lead their readers to believe that every living organism requires or uses all 2000 enzymes, but qualify this assumption by using the words "for the most part"

(1981: 23). In other words, some life, probably the simplest, uses fewer enzymes; even if *all* extant organisms required 2000 enzymes it would not follow that the first life did. It almost certainly did not. (For further discussion of this and the next assumption, readers should refer to <http://www.infidels.org/library/modern/richard_carrier/addendaB.html>. For a good introduction, with numerous recommended readings, on the current state of the science of biochemical origins, see Pigliucci 1999). Other works by Hoyle and Wickramasinghe use pretty much the same arguments and suffer from the same shortcomings (Hoyle and Wickramasinghe 1993; Hoyle 1982).

In an interesting case of one anti-evolutionist's misquoting another, David Noebel (1991: 328) quotes from Luther Sunderland (1984: 60), who bases his statements on Hoyle (1981; thanks to JJ Lowder for pointing me to this classic example). Citing Sunderland, Noebel writes: "[Hoyle] wrote in the 19 November 1981 *New Scientist* that there are 2000 complex enzymes required for a living organism but not a single one of these could have formed on earth by random, shuffling processes in even 20 billion years." Note that Sunderland actually gets the argument wrong: Hoyle specifically says (in Hoyle 1982) that one of these enzymes *can* be formed by random processes; it is getting all 2000 together at once that is supposedly impossible. In the article cited by Sunderland, Hoyle does not mention the numbers 2000 or 20 billion, so Sunderland clearly had Hoyle and Wickramasinghe on hand, yet he ignores Hoyle's qualifying statement there and instead combines these claims with a different claim from Hoyle (1981).

In the article, Hoyle says: "the combinatorial arrangement of not even one among the many thousands of biopolymers on which life depends could have been arrived at by natural processes here on the earth" (1981: 526). Hoyle never explains how he arrives at this conclusion by presenting the factual basis of his calculations; rather, he simply asserts that the appearance of these combinations is akin to 10^{50} blind people's all solving Rubik's cube at exactly the same time (with odds against each success being 4×10^{19}). If we calculate the odds against "arriving by random shuffling of just one of the many biopolymers on which life depends" based on this analogy, we arrive at 1 in $(4 \times 10^{19})^{50}$ — a figure that appears nowhere in any of Hoyle's publications on this problem. Indeed, it directly contradicts what he says in his book published in the same year and in all of his books published since.

John D Barrow and Frank J Tipler

Among the other attempts to demonstrate statistically the improbability of human evolution is *The Anthropic Cosmological Principle* by John D Barrow and Frank J Tipler (1986). Though the authors spend over 600 pages to prove their point, the crux of their argument is clear on page 565: "The odds against assembling the human genome spontaneously is even more enormous: the probability of assembling it is between $(4^{180})^{110\,000}$... and $(4^{360})^{110\,000}$....These numbers give some feel for the unlikelihood of the species *Homo sapiens*." Of course, these overwhelming odds are only relevant if we assume, in their words, "spontaneous assembly". Evolutionary biology has never postulated the "spontaneous assembly" of the human (or any other) genome, and the facts establishing evolution demonstrate that it absolutely did not happen. Thus, like Foster and Hoyle, Barrow and Tipler completely ignore the historical fact of evolution and the role of natural selection on the processes they are trying to model in their calculations. As a result, their calculation has absolutely no relevance to the real question of whether human *evolution* is improbable.

They also produce another calculation, stating that "if we take the average gene to have 1800 nucleotide bases ... then 180 to 360 ... are immutable for each gene" so that "the odds for assembling a single gene are between 4.3×10^{109} and 1.8×10^{217}" (1986: 565). However, once again, the first life would require only the *smallest* replicator, not the *average* one, to begin, so their calculated value tells us nothing about the odds against life's forming. Their calculation also assumes that only one gene of such a length would be viable — but we know that there are billions of different viable genes of such a length. So this does not tell us the odds against random assembly of a gene; it tells us only the odds against the assembly of a single *specific* gene of a particular length, ignoring the fact that many genes of this length and other lengths may work.

Walter Bradley and Charles Thaxton

One of the most sophisticated attempts yet to prove the impossibility of natural processes' producing life on earth was published by Walter Bradley and Charles Thaxton (1994). Despite their more sophisticated approach, their article suffers from the same fallacies as the others. For example, they tell us that "if a protein had one hundred active sites, the probability of getting a proper assembly would be ... 4.9×10^{191}" (1994: 190). Of course, they do not mention that this is true only if the first replicating protein had to be exactly, and only, 100 amino acids in length, and only if no other protein could get life started. When we account for the fact that millions of possible proteins of dozens of different sizes might be suitable to get life started, the odds against life's starting this way are not so daunting. Bradley and Thaxton also assume that all and only the 20 standard amino acids must be involved. But since there are thousands of amino acids, and for all we know any combination of any of them may have begun a replicating lifeform, it follows that their assumption of the 20 standard varieties — no more and no fewer — also is an unreasonable restriction not supported by the scientific evidence that thus invalidates their estimate.

Thaxton, Bradley, and Roger L Olsen have their own book, *The Mystery of Life's Origin* (1984), which contains essentially the same argument with the same flaws. In that book they "assume that we are trying to synthesize a protein containing 101 amino acids" and then determine "the inverse of the estimate for the number of ways one can arrange 101 amino acids in a sequence" to produce a probability of 1×10^{-117}. But they again assume in this calculation that exactly 20 types of amino acid must be involved, no more or fewer (1984: 145). Then they argue that "this ratio gives the fraction of polypeptides that have the right sequence to be a protein", but, of course, this value is only for *one specific* protein sequence, and any number of the 1×10^{117} others could have been constructed and might be equally viable. What is more interesting is that Thaxton, Bradley, and Olsen take this meaningless value and then estimate that "the number of polypeptides that would

be formed during the assumed history of the earth would be ... 10^{72}" so "the probability of producing one protein of 101 amino acids in 5 billion years is only" 1×10^{-45} (1984: 146). Of course, contrary to what they wish to conclude, this number is within the realm of the possible (Borel 1962), so they try to lower the probability by adding the condition that all these acids must be left-handed. This change produces odds — 1 in 10^{175} — that exceed the Borel threshold of "possibility" (1984: 157). However, as I note above in my review of Coppedge, the real result of restricting amino acids to their left-handed forms is to produce chains that are *more* likely than mixed chains to endure for longer periods and to form on crystal surfaces and in other environments. This may not increase the probability of their forming in the first place, but it makes their survival and persistence more — not less — likely than chains that contain both right- and left-handed forms.

Gerald Schroeder

At least one recent attempt at calculating the odds of life's appearance is distinctive for its correct use of the mathematics of probability, even though it is plagued with incorrect starting assumptions. Indeed, Gerald Schroeder (1997) even appears to prove the case for the natural origin of life — but then tries to wiggle out of this apparent conclusion by pointing out certain unacceptable "concessions" that he claims to have made in his calculations which, according to him, render his own conclusions implausible!

Even though Schroeder does not provide a numerical estimate of the odds against life's natural emergence, he presents an argument based on a statistical model and logical conclusions drawn from that model. Indeed, his own calculations lead him to the conclusion that, in fact, it is possible for the specific structure to appear "within the time frame presented by the fossil record" (1994: 111). In other words, he concludes that it is possible after all, when all the proper data are taken into consideration.

So how does he turn this around? Schroeder argues that his results must be implausible because "we have boosted the rate of gamete mutations a hundredfold over the highest rates currently reported, while maintaining the conditions that no mutations were fatal and all proper mutations were locked in" (that is, not lost by later mutations; 1994: 112). This, he says, "stretches plausibility beyond its limits." Does it? No — he has presented an empty argument, as an examination of each of his so-called concessions to evolution shows.

First, what does he mean by increasing the "rate of gamete mutations a hundredfold"? Schroeder assumes a population fixed at 100 000 individuals, but a population of 10 million is actually closer to reality for all small life forms (note that a "population" here is not the total sum of all members of a species, but refers to a community in which mating is likely to occur at some point among members). A population with 10 million individuals will have, on average, 100 times the number of mutations as a population of 100 000 without any change in the mutation *rate*. So he has actually not stretched plausibility except by assuming a relatively small population of only 100 000.

Second, Schroeder also assumes that each pair of parents bears only 2 surviving children — a hopelessly implausible assumption to make of simple life forms. Even if fatal mutations outweighed beneficial ones by a billion to one, selection among offspring will favor those with nonfatal mutations, and more so those with neutral or beneficial mutations. Only fatal mutations that activate after reproduction is complete can be passed on. Therefore, Schroeder's plausibility-stretching "concession" is not only plausible but indeed likely.

Third, Schroeder's idea of "lock-in" is also no concession — unless we presume that a very specific outcome must occur. Schroeder's "lock-in" has no bearing on the odds of there being *some* complex final result. It is erroneous to calculate the odds against a *specific* end result and use that estimate as the odds against there being *any* end result. Since the end result is what has actually happened, lock-in on all the genes that did not mutate between their initial and end conditions is not implausible, but a historical fact.

So Schroeder's own conclusion that evolution is actually *plausible* remains unrefuted, despite his irrational claim to the contrary. This must be one of those cases in which someone very competently proves himself wrong, then claims he is right.

Later, Schroeder applies his calculations to the evolution of humans and chimpanzees from a common ancestor. By claiming that "500 000 generations are required for an 83% probability that the first of the 70 000 mutations will have occurred" (1992: 123), he concludes that hundreds of millions of generations are needed to complete the task — too many for a 7-million-year change. But he is mistaken. First of all, his calculations are wrong, because he again assumes that the odds against a *specific* sequence of *specific* genetic changes are the same as the odds against *any* sequence of *any* genetic changes. But even if his mathematical model were correct, his conclusion is wrong: the number of "generations" he calculates to be necessary is *not* inconsistent with a 7-million-year time span. This is because he only calculates the number of mutant *offspring* that are necessary, and not, in fact, the number of generations.

An examination of his mathematical argument shows that Schroeder bases his argument on the improbability of a mutant child's having a mutation in the right place (which he calculates as 3.57×10^{-6}), not the improbability of such a child's existing in any given generation. When we consider a steady population of 100 000, and a birth rate of 5 children per parental pair, we get 500 000 copies of the parental genes per generation (of which only 100 000 will be able to survive, if we assume that this population size is the carrying capacity of the environment). If we assume a rate of mutation of 1 in 100 births (the frequency of Down syndrome alone comes close to this), we will have 5000 mutants per generation. Schroeder assumes one generation to be seven years (but multiplies this by 500 for bogus reasons addressed below).

With these assumptions, Schroeder's own estimate produces $(3.57 \times 10^{-6}) \times 5000 = 1.8\%$ as the probability that a mutation will occur in the right place and get things started, in only a *single* generation, not in the 5000 generations Schroeder uses. If 70 000 mutations are needed in 7 million years, with 7 years to a generation, there are a million generations between the common ancestor and modern species of humans and chimpanzees. This change would require one mutation

every 14 generations or so. That gives us 70 000 mutants (5000 mutants per generation times 14 generations) and a probability of 25% that enough mutations would have occurred over this time period [$(3.57 \times 10^{-6}) \times 70\,000 = 24.99\%$]. In other words, even using his own mathematical assumptions, it is easy to show that the required change could have occurred in the given time.

So how does he torpedo this? By inserting, once again, bogus assumptions:

- Schroeder claims that mutation rates in human gametes are fewer than 1 in 10 000 births; since he uses a population estimate of 10 000 (see below), he can claim only 1 mutant per generation. But the mere fact that a single kind of mutation, Down syndrome, occurs once in every 700 births demonstrates that his assumptions are too restrictive and unrealistic.

- Schroeder also assumes a breeding population of 10 000. Limiting the population to 10 000 can be challenged in many ways, but the most telling criticism is that this limitation deviates from his previous practice of assuming a breeding population of 100 000. He provides no justification for limiting the population for this calculation to 10% of his estimates in other parts of his work.

- Schroeder also uses compound interest formulas to conclude that a mutation granting a 1% advantage in reproductive success will take 500 generations to become predominant in a herd of 10 000 (see note 4 at <http://www.infidels.org/library/modern/richard_carrier/addendaB.html>). But this calculation does not take into account that a surplus of individuals in each generation is competing for survival in a population that cannot grow larger than 10 000. Since descendants are competing for limited resources, a small advantage is just as effective as a large one and quickly becomes a windfall. In this case, a 1% advantage will gain the mutant one additional slot within 6 generations; with geometric progression, the mutant line, accidents aside, will fill all 10 000 slots in only 19 generations (a mere 3 centuries for humans). Of course, this process can occur even faster, if changes in the environment also increase mortality and decrease reproduction in competing families. Schroeder's assumption of a steady, mere 1% adaptive advantage for mutants fails to reflect the biological reality.

- Schroeder assumes that a mutation must completely replace pre-existing characteristics before evolution can proceed. But mutations keep happening; they do not wait until previous mutations have totally replaced their predecessors. Many different mutations can occur even during the 20 or so generations it takes for a new mutation to become the prevalent characteristic in a population.This is one reason why populations can so easily branch off into different evolutionary paths. But Schroeder assumes that the next step can only occur *after* the first mutation has prevailed.

Schroeder goes on to cite numerous scientific works to prove the impossibility of the natural emergence of life on earth. But the context of the quotes he uses and the assumptions of the models he cites demonstrate that they reach conclusions that are entirely the opposite of his. His citation of Prigogine's work is a case in point (Prigogine and others 1972). The authors first set out the challenging problem — the fact that contemporary theory did not account for biogenesis — which Schroeder quotes. However, Schroeder ignores their solution, which is mathematically and experimentally proven in the same article, and the conclusion that "the spontaneous genesis of life in its present form" is *probable*, not improbable. So either Schroeder is trying to pull a fast one or he did not read the article.

Schroeder also cites a Wistar Institute conference as showing evidence of the improbability of evolution. Only one paper from the conference comes anywhere near proposing that the origin of life and subsequent evolution are improbable (Eden 1967). Eden argues that no current theory (in 1967) accounts for certain peculiarities of life on earth, especially the fact that all living organisms are composed of a very tiny fraction of all the possible proteins. In the same volume, his critics point out why this is so: once one system involving a score of proteins was selected, no others could compete even if they were to arise, thus explaining why all life has been built on one tiny set of proteins. Schroeder fails to mention this.

Henry Morris

No discussion of irrelevant statistics would be complete without the ever-popular *Scientific Creationism* by Henry Morris (1974). This is littered with all the same mistakes noted above, all of which are refuted by the arguments rehearsed above. The popular 100–amino-acid chain appears (1974: 60–1); Morris calculates the odds of a chance arrangement of exactly one such chain as 1 in 10^{158} and the odds against this happening in the known age and expanse of the universe as 1 in 10^{53}. Of course, as with the other anti-evolutionary writers, all of Morris's assumptions invalidate the conclusions — that life can only start with a chain of exactly 100 amino acids and with only one arrangement of such a chain, that only 20 specific amino acids are necessary, and so on. He cites Morowitz (1968) to support his claim that a chain 100 units long would be too small to function.

Morris then draws on a woefully outdated and arbitrary idea (Golay 1961) that 1500 sequential steps are needed to achieve a "protein molecule" (1974: 64–5). Morris calculates the odds of this ever happening as 1 in 10^{450}. But he makes exactly the same mistake as Foster did by ignoring the 3 fundamental features of natural selection: reproduction, mutation, and selection. Morris also assumes that only one sequence of 1500 steps will begin life — even though there may be millions of different sequences that will work and there may be many different numbers of steps.Any appropriate derivation of odds must sum the odds for all possibilities, that is, the odds for every possible number of steps and of every arrangement of steps that will produce a reproducing protein.This is impossible to know. Such a statistic cannot be calculated, even using Morris's calculations.

Finally, Morris arrives at the value of 1 in $10^{299\,843}$ against the natural origin of life (1974: 69).Where does he get this? It is the result of multiplying the sequential odds against a million mutations' occurring in just such a way as to produce a horse (à la Huxley)! Morris, of course, ignores the way that selection can affect probabilities of successive events and also assumes that the goal is to produce a single specific genome. Even on his

own flawed assumptions, these are not the odds against life's evolving, but the odds against a *specific individual horse's* evolving. Morris makes no attempt to account for the fact that there are trillions and trillions of viable horse genomes, and trillions and trillions and trillions of genomes that correspond to viable life forms of any kind. One cannot simply calculate the odds against a single individual person's being just as he is and use that calculation as the odds against the existence of any person, or any life of any kind. Just because every hand in poker has the same odds of being dealt as a royal flush in spades, it does not follow that the odds of any hand's being dealt are the same as the odds of a royal flush in spades.

Dean Overman

Dean Overman is a recent contender who bases his work on the flawed foundations already refuted above. His own arguments are either vacuous attacks on straw men or full of deceptive omissions. For example, he cites Küppers (1990: 59–60) on the impossibility of the random assembly of a bacterial genome (1997: 64–5). Of course, biologists consider bacteria to be the highly advanced outcome of millions of years of evolution from a beginning that is unknown to us; no evolutionary biologist endorses the idea that bacteria are the original life form. But Overman is deceiving his readers in another way. Küppers uses this problem as a study question to explore how random processes can produce an ordered complexity (Küppers himself acknowledges that the set-up is fictitious). The rest of Küppers's book then shows that ordered complexity can indeed arise from random selective processes. His proof is mathematically rigorous and decisive. Overman's failure to mention this to his readers demonstrates how little he is to be trusted.

Overman also claims that in biologists' writing "the term 'environment' is endowed with characteristics including powers of intelligence to ...'know what kind of organism is best and reject wrong letters or sequences'" (1997: 56). Although it is true that the selection analogies he criticizes are admittedly oversimplified, it hardly follows that his own totally random calculation is more realistic. Instead, Overman tries to use his straw man to argue that natural selection assumes a "Superior Intelligence" (1997: 57). Overman thinks this process is "intelligent" because he assumes, quite wrongly, that only one outcome is "correct". Using the analogy of producing a 379-letter passage from Shakespeare by random placement of letters (1 in 10^{536}; 1997: 54–5), he makes it appear that scientists are arguing that "arriving at *this* Shakespearean sonnet" is the only possible outcome. What Overman does not tell his readers is that it is more correct to say that *any* legible and grammatically correct sonnet counts as a possible outcome, not just one specific sonnet. In the terms of his own analogy, nature produces paragraphs more and more legible over time, without any rules except those set by the environment, and in time millions of fully legible paragraphs will be produced. One of those paragraphs will likely be a part of a specific Shakespearean sonnet, but that is not necessary, since some kind of legible sonnet will result — in fact, millions of them.

Overman has two other shoddy arguments that should be mentioned, although neither of them has anything to do with any specific calculations that he makes. First, he says "natural selection does not exist in prebiological molecules" (1997: 56). This is irrelevant because, as long as a random first replicator is *possible*, we do not need natural selection to explain the *emergence* of life, only its subsequent development. As I have noted several times previously, there is no sound argument that the odds against the emergence of a simple first replicator are high enough to make it incredible.

His second argument (1997: 76) is that Prigogine's work confuses order (such as in a crystal) with complexity (such as in a printed page). In support of this, he cites Yockey (1981: 20 and 1992: 245, 289). But these citations are not relevant to the question. We do not know how "complex" the first replicator had to be or could have been, nor do we know how many were possible. But once the first replicator formed, complexity would be an predictable outcome of mutation and selection.

Moreover, Overman's entire reading of Prigogine — and his citation of Yockey — is wrong. Prigogine's (1972) paper demonstrates quite conclusively that large numbers of very long polymers can be naturally produced within the confines of the laws of thermodynamics and that they will not just be strings of identical amino acids. He also demonstrates the existence of a form of prebiotic selection, wherein randomly produced polymers catalyze a certain chemical faster than competing polymers, and thus the catalysis process "favors" certain products over others. With several such cycles engaging, complexity can arise in a "selective" system even without genuine reproduction.

Guy Cramer

Two additional but inferior claims are cited in the online essay "The crutches of atheism", by Guy Cramer (1998). The first is based on Mark Ludwig's *Computer Viruses, Artificial Life and Evolution* (1993), in which the odds against the spontaneous assembly of the *E coli* bacterium are assumed to be equivalent to the odds against the formation of life. Ludwig calculates this as somewhere between 1 in $10^{2\,300\,000}$ and 1 in $10^{3\,000\,000}$ (1993: 274). Of course, *E coli* is a highly advanced organism, the end result of billions of years of evolution, not the first organism or anything like it. This is the same mistake made by Coppedge, and the calculation of these odds is irrelevant for the same reasons. Cramer then adds to the irrelevance by claiming that the odds against uniform chirality in the *E coli* genome are 1 in $10^{3\,600\,000}$. But this calculation also repeats the mistake of Coppedge and many others. Accidental uniform chirality ("homochirality") for an organism as simple as the *tetrahymena* would be nowhere near as improbable. Cramer is also assuming that uniform chirality must necessarily be random, when there are several possible nonrandom causes, as discussed previously.

Cramer also quotes organic chemist William Bonner, who wrote "Terrestrial explanations [of homochirality] are impotent and nonviable" (cited in Cohen 1995). Cramer claims that this view must be respected because Bonner is "the world's leading homochiral researcher" but fails to mention that his source for Bonner's quote clearly explains that there are several leading homochiral experts who *disagree* with Bonner and who have other very plausible ideas. Moreover, Cramer fails to tell his readers that Bonner actually believes that homochiral molecules can be manufac-

tured naturally — for example, in a supernova — and that these odds are only against a *terrestrial* source of such molecules. Thus Bonner's opinion does not really support the anti-evolutionist position that life is too improbable to have emerged naturally.

Conclusion: One Pervasive Error Plagues Them All

There is still one fundamental problem with all these statistical calculations: no one knows what the first life was. People like Morowitz can try to calculate what is possible, at a minimum, and laboratory experiments, such as those that discovered the powers of *tetrahymena* (Shapiro 1988), can suggest possibilities. However, these possibilities do not count as knowledge. Although they serve to guide scientists in asking questions, developing hypotheses, and constructing theories, they really do not solve the problem.

Theories that make the origin of life plausible are awaiting future research — in fact, these theories are *generating* that research. On the other hand, in the words of Frank Salisbury, "Special creation or a directed evolution would solve the problem of the complexity of the gene, but such an idea has little scientific value in the sense of suggesting experiments" (1969: 343). And the experiments suggested by Salisbury and his colleagues led, in fact, to a simplification of the very problem that vexed Salisbury in 1969. Science, once again, gets somewhere.

Coppedge suspected in his day "many evolutionists have avoided such investigations [into the odds against life forming] because they intuitively recognize that it will threaten evolutionary doctrine" (1973: 234). Yet scientists have hardly avoided the matter at all. Quite to the contrary, while anti-evolutionists rehashed their old calculations for 25 years and contributed nothing to our understanding of biology, scientists chewed away at the very problems Salisbury and Coppedge discussed and solved a great many of them (see Kauffman 1993). That none of them thought to make arbitrary and groundless guesses for the purpose of calculating a useless probability is testament to their wisdom.

References

Barrow JD, Tipler FJ. *The Anthropic Cosmological Principle.* New York: Oxford, 1986.

Borel E. *Probabilities and Life.* Baudin M, translator. New York: Dover, 1962. Translation of *Les Probabilités et la Vie.*

Bradley W, Thaxton C. Information theory and the origin of life. In: Moreland JP, editor. *The Creation Hypothesis: Scientific Evidence for an Intelligent Designer.* Downer's Grove (IL): InterVarsity Press; 1994. p 173–234.

Cohen J. Getting all turned around over the origins of life. *Science* 1995 Mar 3; 267: 1265–6.

Coppedge F. *Evolution: Possible or Impossible?* Grand Rapids (MI): Zondervan, 1973.

Cramer G. The crutches of evolution. 1998. Available at <http://www.yfiles.com/crutches.html>; last accessed January 29, 2001.

Eden M. Inadequacies of neo-Darwinian evolution as a scientific theory. In: Moorhead P, Kaplan M, editors. *Mathematical Challenges to the Neo-Darwinian Interpretation of Evolution, a Symposium Held at the Wistar Institute of Anatomy and Biology April 25 and 26, 1966.* Philadelphia: Wistar Institute, 1967. p 5–20.

Foster D. *The Philosophical Scientists.* New York: Barnes & Noble Books, 1993.

Golay M. Reflections of a communications engineer. *Analytical Chemistry* 1961 Jun; 33 (7): 23A.

Hoyle F. The big bang in astronomy. *New Scientist* 1981 Nov; 92: 521–7.

Hoyle F. *Evolution From Space (The Omni Lecture) and Other Papers on the Origin of Life.* Hillside (NJ): Enslow, 1982.

Hoyle F, Wickramasinghe NC. *Evolution From Space: A Theory of Cosmic Creationism.* New York: Simon & Schuster, 1981.

Hoyle F, Wickramasinghe NC. *Our Place in the Cosmos: The Unfinished Revolution.* London: Dent, 1993.

Hud N, Anet FAL. Intercalation-mediated synthesis and replication: A new approach to the origin of life. *Journal of Theoretical Biology* 2000; 205: 543–62.

Huxley J. *Evolution in Action.* London: Scientific Book Club, 1953.

Kauffman S. *The Origins of Order: Self-Organization and Selection in Evolution.* Oxford: Oxford University Press, 1993.

Küppers B-O. *Information and the Origin of Life.* Cambridge (MA): MIT Press, 1990.

Ludwig M. *Computer Viruses, Artificial Life and Evolution.* Tuscon (AZ): American Eagle Publications, 1993.

McIver T. *Anti-Evolution: A Reader's Guide to Writings before and after Darwin.* Baltimore: The Johns Hopkins University Press, 1992.

Morowitz HJ. *Energy Flow in Biology.* New York, Academic Press, 1968.

Morowitz HJ. Biological self-replicating systems. In: Snell F, editor. *Progress in Theoretical Biology.* New York: Academic Press, 1969.

Morris HM. *Scientific Creationism.* Green Forest (AR): Master Books, 1974.

Musgrave I. Lies, damned lies, statistics, and probability of a biogenesis calculations. Available at <http://www-personal.monash.edu.au/~ianm/prob.htm>; last accessed November 3, 2000.

Noebel D. *Understanding the Times.* Eugene (OR): Harvest House Publications, 1991.

du Noüy PL. *Human Destiny.* New York: Mentor (New American Library), 1947.

Overman D. *A Case Against Accident and Self-Organization.* Lanham (MD): Rowman & Littlefield, 1997.

Pigliucci M. Where do we come from? *Skeptical Inquirer* 1999 Sep/Oct; 23 (5): 21–7

Prigogine I, Nicolis G, Babloyantz A. Thermodynamics of evolution. *Physics Today* 1972 Nov; 25: 23–8; Dec; 25: 38–44.

Quastler H. *The Emergence of Biological Organization.* New Haven (CT): Yale University Press, 1964.

Sagan C, Crick FHC, Muhkov LM. Extraterrestrial Life. In: Sagan C, editor. *Communication with Extra-Terrestrial Intelligence.* Cambridge (MA): MIT Press, 1973. p 42–67.

Salisbury F. Natural selection and the complexity of the gene. *Nature* 1969 Oct 25; 224: 342–3.

Salisbury F. Doubts about the modern synthetic theory of evolution. *American Biology Teacher* 1971 Sep; 33 (6): 335–8, 354.

Salisbury F. *The Creation.* Salt Lake City: Deseret Book Co, 1976.

Schroeder G. *The Science of God: The Convergence of Scientific and Biblical Wisdom.* New York: Free Press, 1997.

Shapiro R. Prebiotic ribose synthesis. *Origins of Life and Evolution of the Biosphere.* 1988; 18: 71–85.

Sunderland LD. *Darwin's Enigma.* San Diego (CA): Master Book Publications, 1984.

Thaxton CB, Bradley W, Olsen RL. *The Mystery of Life's Origin.* New York: Philosophical Library, 1984.

Trevors JT. Evolution of bacterial genomes. *Antonie van Leeuwenhoek International Journal of General and Molecular Microbiology* 1997 Mar; 71(3): 265–70.

Yockey H. A calculation of the probability of spontaneous biogenesis by information theory. *Journal of Theoretical Biology* 1977; 67: 377–98.

Yockey H. Self organization origin of life scenarios and information theory. *Journal of Theoretical Biology* 1981; 91: 13–31.

Yockey H. *Information Theory and Molecular Biology.* New York: Cambridge University Press, 1992.

[*This article was adapted from Richard Carrier's review of David Foster's* The Philosophical Scientists, *which appears at <http://www.infidels.org/library/modern/richard_carrier/addendaB.html>.*]

Author's Address

Richard Carrier
Electronic Texts Service
Room 305 Butler Library
Columbia University
New York NY 10027
rcarrier@infidels.org

Design and its Critics: Yet Another ID Conference

Jeff Otto with Andrew Petto

Concordia University in Mequon, Wisconsin, was the site of another "Intelligent Design" conference held on June 22–24, 2000. Under the rubric "Design and Its Critics" (DAIC), the conference brought together the leading lights of the "Intelligent Design" (ID) movement with several critics from a variety of disciplines in the natural sciences, social sciences, and humanities (*see program outline in sidebar, p 39*). There was a variety of plenary and concurrent sessions throughout the weekend, so we are able to present only the highlights of the conference.

Thursday, June 22, 2000

The opening debate was on Thursday night. Stephen Meyer and Michael Shermer shared the stage. Meyer's talk was entitled "What do good scientific theories do?" According to Meyer, they explain data in the natural world and make predictions about the natural world — particularly predictions that are useful for future scientific research. Because explanation is not equivalent to prediction, Meyer argued, *historical* theories can accomplish only the first task; they can retrodict but not predict. ID also accomplishes the first task: it has explanatory power. Meyer's example was the concept of irreproducible complexity introduced in Behe's discussion of the bacterial flagellum.

Meyer went on to claim that ID provides a better explanation than evolutionary theory in several instances. First, Meyer argued that ID provides a better explanation of the origin of "information", in particular the origin of DNA, than does evolution. Next he claimed that ID provides a better explanation of the Cambrian Explosion — the sudden appearance of new phyla in the fossil record 570 million years ago — because new organisms require a new information code. According to Meyer, this situation does not fit a "Darwinian" model, because the mere shuffling of genes is not sufficient to produce this variety (though he provided no support for this assertion). In Meyer's view, the shortcomings of evolutionary models confirm ID by default.

Meyer rehearsed the standard mistaken creationist critiques based on biochemical complexities and specificities of *modern* organisms, but added an interesting — if misconstrued — discussion of the origin of DNA. Since DNA provides the instruction set for proteins, Meyer asked, what is the causal explanation of the DNA code? Citing Stanley Miller's experiments as proof that the prebiotic atmosphere was unsuitable for sustaining life, Meyer concluded that there was no natural prebiotic source of the information encoded in DNA. Any precursor molecules would be subject to interfering cross-reactions, and the limited time and resources combined with the required sequence specificity (for a fully functioning 100–amino-acid protein) would have precluded *de novo* synthesis. Meyer tried to apply a version of Dembski's "explanatory filter", arguing that the low probability and the complex specification of the DNA molecule require us to conclude that it had been designed.

The main focus of the rest of Meyer's presentation was the supposed evidence for the design of DNA — the information content of living things. Meyer argued that natural selection cannot explain the *origin* of information, because it presupposes a freely replicating system — one that operates on DNA and protein (of course, natural selection is not concerned with, nor does it try to explain, the *origin* of "information"). Furthermore, Meyer argued that there are no forces in evolutionary theory to explain the sequential order of DNA, apparently because he believes that, according to evolutionary biologists, nucleotide base organization should be random. Of course, in most organisms many repetitive sequences in DNA, noncoding introns ("nonsense" DNA), and "junk" DNA are not constrained by strict sequential relationships. These random elements constitute a very large fraction of the genome.

Meyer constructed a straw man by focusing on DNA and fully functioning proteins. No working evolutionary scientist believes that life originally appeared fully equipped with the present complex DNA and protein repertoire. One leading theory of early life is the RNA world hypothesis, about which, in the question period, Meyer showed that he is absolutely misinformed, falsely claiming that RNA could neither replicate nor make peptide bonds. The question period ended before he could be fully questioned on this topic, but there are several published papers that show that Meyer was attacking strawman arguments about DNA, RNA, and information origin (Zhang and Cech 1997, Wright and Joyce 1997).

Michael Shermer took the stage next. His presentation was more theatrical (complete with a laser pointer that projected the shape of a UFO). He made some very good points, but I do not think that most of the audience was sufficiently engaged by his presentation. Natural selection, Shermer said, preserves gains and eliminates mistakes; "Intelligent Design" assumes that the current function of structures in living things is the same as the original function. He argued that ID is not useful scientifically because it leads to an investigative dead end — the actions of an intelligent designer.

Jeff Otto is a researcher at Genaissance Pharmaceuticals. Andrew Petto is the editor of RNCSE.

FRIDAY, JUNE 23, 2000

The first plenary session was entitled "Design in the Biological Sciences". Michael Behe spoke first. He read from a prepared text, saying that he has learned that he must be particularly careful in what he says. His main point was that there are irreducibly complex (IC) structures — structures that could not have been produced by numerous successive small changes without loss of function. Natural selection, which Behe restricts to such small, successive changes, would be unable to explain the existence of such structures. His examples of IC structures were the mousetrap — a 5-piece machine that is rendered nonfunctional by the removal of any piece — and the bacterial flagellum — a complicated, molecular "machine" that may be the biochemical equivalent of the mousetrap.

Behe next responded to Ken Miller's *Finding Darwin's God*. He focused on the *lac* operon — a genetic sequence in *E coli* bacteria that regulates the production of 3 enzymes necessary for the digestion of lactose. If any component of this multipart system is eliminated, argued Behe, the system becomes nonfunctional. Although Kenneth Miller had cited experiments showing that when the one of the *lac* operon genes — the β-galactosidase gene — is knocked out, bacteria can re-acquire this function, Behe disputed this conclusion, because, he said, it was necessary to generate an artificial system using "intelligent intervention" that added other components to the system before the function could be restored.

Behe's next example of IC was the blood-clotting cascade. Behe illustrated the complexity of this system and claimed that removal of any of the components is highly deleterious and causes the whole process to collapse. Citing research with transgenic organisms, Behe argued that these systems are irreducibly complex, because they contain many parts that must be well coordinated with one another to function — therefore, they could not have arisen by natural selection working through gradual, Darwinian mechanisms.

Next up was Scott Minnich, whose talk focused on the research on the bacterial flagellum. He gave a very nice, purely scientific talk on research in the field, which did not seem to fit in here because it seemed that a substantial part of his talk *contradicted* the assertion of irreducible complexity. For example, he discussed the virulence plasmid found in the bacterium that causes bubonic plague, which, as it turns out, contains several genes that are highly homologous to those that code for flagellar proteins. In the plasmid, these genes code for proteins that make up structures that drill holes into host cells and inject them with poison. Here we have an example where one set of genes codes for flagellar proteins, while a homologous subset of those genes codes for an entirely different structure (a hole-drilling apparatus). In an IC structure, if a single component is removed, the structure loses its specific function. But complex structures need not lose *all* physiological function when one component is changed. The exaptation of an existing structure — such as occurs in the protein products of the virulence plasmid — to a structure performing a new function — such as the flagellum — is precisely the sort of change evolution would predict. Minnich's example endangers only the straw man position that these cellular structures must preserve their *existing* functions as their protein composition or sequence is modified.

Ken Miller spoke next, presenting a step-by-step, systematic critique of Behe's argument. First he pointed out, in contrast to the assumptions of IC, that no scientist proposes that complex macromolecular systems spontaneously arose in their currently functioning state. Instead, individual components of the larger system probably had other functions, and, through gene duplication or other mechanisms, they took on new functions. These processes permitted the acquisition of new functions and opportunities to interact with other molecules to provide intermediaries with novel functions.

Miller spent a great deal of time describing how the flagellum might have evolved, providing numerous examples of organisms that illustrate the mechanisms and processes that he proposed. He also gave examples of flagella that have some components missing but still function. The example that made the best impression on the audience was that of eel sperm. The missing components make the flagellum *appear* nonfunctional, said Miller, but, he reminded the audience, since these sperm are very good at making baby eels, the flagellum clearly *must* function — despite its having "missing" parts.

Next Miller discussed the Krebs cycle — a series of chemical reactions common to living things that extracts energy from carbohydrate molecules — showing how a variety of organisms use different parts of the cycle for different functions. All the while Miller reminded the audience that according to IC, the loss or alteration of one component from an IC system makes the system nonfunctional. At the same time, he reminded the audience that complex systems evolve by co-opting pre-existing, functioning components to serve new functions in new ways.

Miller also presented a bibliographic search (on Medline) showing that there have been only 2 articles on IC in the peer-reviewed literature since 1966, neither one of which appeared in a peer-reviewed *scientific research* journal. Finally, he took on the central "commonsense" analogy of IC — the irreducibly complex mousetrap. He demonstrated fully functional 5-part, 4-part, 3-part, 2-part and even 1-part mousetraps, concluding by pointing out how, as in biology, the mousetrap that serves one function can be adapted for others (he cited the mousetrap key chain and the mousetrap tie-tack).

A question-and-answer period followed the presentations. As might be expected, Behe took exception to many of Miller's criticisms, denying that he had ever said the things for which Miller took him to task. This is a dangerous tactic in the digital age when your opponent is armed with a laptop computer. Miller was able to provide precise quotations and citations from Behe's work to support his claims. Behe was backpedaling throughout the entire session, and not many questions were asked of the speakers.

During this session, I (JO) introduced myself as a population geneticist from Rush Medical Center in Chicago and said that I had 3 related observations that led

to a practical question. First, my research focuses on the identification of genes responsible for complex autoimmune diseases. Evolutionary theory provides the basis for the genetic algorithms that I use in my research. Second, 2 weeks earlier I had visited a pharmaceutical company that also uses evolutionary algorithms to aid in the identification of different alleles affecting drug-metabolizing enzymes. Third, I recently met a researcher at Marquette University who uses evolutionary algorithms to aid in identification of amino-acid residues critical for function of a very complex protein. My question — an open question to both of the ID proponents — was: As practical people, looking for the fastest, most efficient method to reach our goals, how would Intelligent Design help us in our endeavors? What would ID predict in these different systems?

Behe answered the question by commenting that ID would tell us where to look, and perhaps which systems would be irreducibly complex. I replied that his answer really did not answer my question. In the real world of scientific research, I reiterated, evolutionary theory provides algorithms that suggest how to go about finding what we are looking for; these algorithms are used successfully in many fields — including by pharmaceutical companies that are primarily interested in making money. How would ID provide a superior model for accomplishing these goals? Behe answered by mumbling something about needing to see what algorithms I am using. Then the session was closed.

My question sparked discussion afterwards, and I had opportunity to talk with quite a few different people. The general consensus of these people (with the exception of one oddball who basically contended that we are all "de-evolving" into the blackness of Hell) was that my question really went to the crux of the issue of whether ID has anything useful to present to the scientific community. Scientific theories not only explain and make sense of our observations, but also provide questions and predictions that support useful and productive research.

Meyer's earlier claim that ID only has power to retrodict is an evasive maneuver that may sound nice in a sound bite. But the fact is that a theory that only retrodicts is a scientifically worthless idea that does not merit the title of theory. ID is based entirely on the assumption that when science reaches a stumbling block, the appropriate response is to throw up one's hands, say "I don't understand how this could be put together naturally", and to claim that it was intelligently designed. In this way ID is actually more scientifically bankrupt than young-earth creationism, which at least makes testable predictions. ID is invoked only when regular science gets stuck (for the moment).

Saturday, June 24, 2000

The main event of the final day of the conference was the talk of ID's undisputed star, William Dembski. Much of the presentation was devoted to an exposition of Dembski's method for detecting design — "The Design Inference" (TDI). Dembski had prepared enough material for several presentations, so he was unable to give more than a fleeting description of the details of TDI. Because there was too much material for the format and time allowed, Dembski skipped over numerous details and omitted connections among important ideas. The result was a presentation that appeared disorganized and disjointed — the lasting impression is of a series of symbolic statements that were meant to show the steps in the explanatory filter that Dembski proposes as the basis for TDI. However, Dembski's presentation was so abridged that these formulas were neither well explained nor clearly related to his TDI. *RNCSE* readers interested in Dembski's method for detecting design should consult Wesley Elsberry's recent review-essay in *RNCSE* (Elsberry 1999).

The second major event on Saturday was a panel discussion entitled "Prospects for Design". The participants were Paul Nelson, Edward Davis, Kelly Smith, and Lenny Moss. Nelson told the audience that the real issue is to provide an argument *against* methodological naturalism (MN), which he called one of the worst philosophies of science. Nelson characterized MN as absolute rubbish and characterized himself as someone interested in getting at the truth about the world. He said that his purpose was to show the limits of MN, not to set out the future direction of ID.

Nelson provided a definition of MN based on the characterization by the National Academy of Sciences (NAS): "The statements of science must invoke only natural things and processes" (NAS 1998: 42). Nelson's question to the audience was, "Should this be so? Should we separate the natural from the supernatural?" Nelson argued that we should discard the supernatural–natural distinction in favor of the intelligent–natural distinction. We should, Nelson said, institute a research program for intelligent causation — but true to his promise, Nelson did not suggest what such a program would entail.

Most of Nelson's presentation was an exploration of how MN supposedly limits our ability to find out what is true. In Nelson's example, a homicide detective faced with a dead body must consider 4 possible explanations in order to determine the real cause of death. Two of these require no intelligent agent — natural causes and accidents — but the other 2 are caused by the actions of just such an agent — suicide and homicide. According to Nelson, MN would limit the homicide detective's investigation to death by natural causes or accident and would leave out suicide and homicide — both actions of an intelligent agent. In the real world, Nelson argued, even if death were never to occur by suicide and homicide, they would remain causal probabilities — that is, they *could* occur — and, according to Nelson, if we do not consider homicide and suicide to determine that they do *not* explain the death we are investigating, then we cannot know for sure that our explanations are true. Unless he considers and rules out the possibility of murder and suicide, the detective cannot be justifiably confident that he has solved the case. Likewise, Nelson argued, we should not exclude intelligent design from the scientific "toolkit".

According to MN, Nelson told the audience, the tools in the scientific toolkit are natural laws (Nelson called them "physical" laws) and chance. Nelson argued that a third tool, intelligent design, belongs in

the toolkit of science too. Even if we never need to invoke ID, Nelson told the audience, a naturalistic interpretation of evidence can never be completely justified unless ID is considered and ruled out. Even Darwin lived and worked in an environment with all 3 tools, said Nelson, and it did no harm to his science. Likewise, Nelson assured us, it will do no harm for us to consider ID when the evidence warrants it.

In summary, Nelson argued that science cannot discover what it excludes *a priori*. If science is a truth-seeking endeavor (as he assumes), then MN belongs on the rubbish heap of history because it limits scientists to a flawed investigative process that fails to include all the explanatory possibilities.

Edward Davis spoke next. He said that he accepts that there is purpose in the universe, although he has concerns about how the issues are framed in the current models of ID. He chose to explore how we understand the meaning of apparent design in Nature through recent research that he has been conducting on the works of Robert Boyle — a 17th-century chemist and natural philosopher best known for his laws about the behavior of gases and his use of controlled experiments.

Although Boyle argued for "design" in the natural world, Davis pointed out that this design represented neither ongoing tinkering by an intelligent agent nor what passed for the 17th-century version of the anthropic principle — a philosophy of science that assumed that Nature was constructed benevolently to promote human well-being. Instead, although Boyle was convinced that experimental science would demonstrate the existence of God, he felt that the route to this demonstration was through an understanding of the mechanics of the way things really worked in the natural world. In Boyle's view, God works through the "mechanisms" that show his presence and actions. Boyle felt that the scientific process is short-circuited by teleological explanations, even if there is an ultimate purpose to the universe. He thus insisted on naturalistic explanations for natural phenomena first and foremost whenever possible.

Although he told the audience that he agreed that evidence of purpose is found in the natural world, Davis argued that it is neither appropriate nor productive to look for it in the same ways and places that one looks for evidence of natural processes. Davis told the audience that he believes "in a God who is sovereign over the laws of Nature". However, he noted, the world is not full of items stamped "Made by God"; God is more subtle than that. So the evidence for God's purposes may not be the same physical evidence that we find in natural phenomena that scientists study, say, in the behaviors of gases under pressure or mutation rates.

The most serious problem with ID, Davis told the conference, is that it appears to make the existence of God (the unnamed "intelligent designer") an additional hypothesis to be tested scientifically. However, this runs counter to the central understanding of God in Christian and Jewish traditions. Davis told the audience that the central claim of Christianity, for example, is that we have actually seen God directly, and when we did not like what we saw, we killed him — then he surprised us. Davis said that we need to incorporate the interaction between God and the world into our discourse in this way, not as specific scientific hypotheses about individual events and structures.

The next speaker was Kelly Smith. He presented a "blueprint for respectability" — an outline for how ID could earn itself a place at the scientific table. Smith's remarks are included later in this issue (*see p 40*). In summary, he outlined a program that would turn ID from a fringe idea to a respectable theory in the sciences, along with all the benefits that respectability offers — respect, funds, access to classrooms, and a place in mainstream textbooks and journals. This was the route taken by all *successful* challengers to the scientific *status quo*. But he doubted that ID proponents would take his advice.

The last speaker in the panel was Lenny Moss, who argued that the key issue under discussion was the nature of Nature. According to Moss, ID assumed a very narrow notion of Nature, defining its position by its opposition to the viewpoints of a few prominent proponents of philosophical naturalism, such as Richard Dawkins and Daniel Dennett. Moss argued that ID, if it is to be successful, needs to define itself in its own terms, not merely in opposition to what are extreme positions even among natural scientists.

Taking Dawkins and Dennett to task is a good tactical approach, Moss told the conference, for it allows the proponents of ID to press the naturalistic explanation and show where it is in trouble — a debunking strategy. However good a *tactical* approach it may be to oppose what he called the strict neo-Darwinism of Dawkins and Dennett, Moss said, it is nonetheless a bad *strategic* approach. That is, to accept that naturalism is restricted to the premises of neo-Darwinism "sells Nature down the river" by restricting naturalism to a particular, limited version of naturalism espoused by Dawkins and Dennett. The most fruitful answer to a dogmatic metaphysics (like that of Dawkins or Dennett), said Moss, is not another dogmatism, but a pluralistic approach. Reacting against a strict neo-Darwinism with a dogmatic approach — whether it is ID or some other dogmatism — leads to bad biology. Instead, Moss argued for a broader perspective for both ID and for naturalism.

In considering the future prospects for ID, there is, Moss said, good news and bad news. As for the good news, Moss argued that science is at a historic juncture — at a new "crisis" in the struggle to resolve our "intuition for life". He traced our understanding of Nature from the 17th century, when science changed its understanding of natural events and organisms as ends unto themselves to a view of these phenomena as the outcome of other natural processes and interactions. This change culminated in the 20th century when, Moss argued, we now understand natural events and organisms as *only* the outcome of natural processes and their interactions. One aspect of this important historic juncture is the Human Genome Project.

Moss told the conference that there are promissory notes that need to be called in — things that biology has promised and not yet delivered. It is time to move beyond the 17th-century view of matter and the physical world to a new scientific understanding that can do justice to the agency of life. This "new naturalism" is one that would allow a pluralistic view of agency in the emergence and direction of life, and one that may make substantial contributions to our understanding of Nature. In reviving a sort of preformationist, vitalistic approach, ID may figure into Moss's "new naturalism".

The bad news for ID is that it seems to be mired in its opposition to a view of the nature of Nature — espoused by Dawkins and Dennett especially — that is more restrictive than the view held by most scientists. Focusing on refuting this more restricted view threatens to push ID onto a path where it will remain tangential and irrelevant to the questions that active scientists pursue and find meaningful.

Moss's example of the new way for science to proceed is taken from the work of philosopher Immanuel Kant. Kant allowed us to have it both ways, Moss said — we can take it as a given that there is an organization in life while at the same time resisting the temptation to try to explain the purpose or first principle of everything. In this way, the "new naturalism" that Moss proposes does not require, presuppose, or even benefit from atheism. In contrast, many in the ID movement seem to be opposed to evolution because Dawkins and Dennett portray it as essential to supporting atheism.

The Big Tent

Throughout the conference there were numerous roundtable discussions, presented papers, and informal discussions over meals and snacks. It was impossible to cover all of these events, and most were not included in the official record of the conference. The sessions we attended resembled the plenary sessions: Some were thoughtful and well-researched presentations of important questions and theoretical perspectives. Others were little more than standard anti-evolutionary fare, concluding that if evolution could not immediately explain some unusual finding or new discovery, then ID had to be true by default. But it was also clear that there were a number of very different ideas about precisely what intelligent design entailed.

The unspoken position of the ID proponents at the conference seemed to be to accept all criticisms of evolutionary theory as evidence that an intelligent agent of some sort was involved in the history of life and in the patterns of similarity and difference that biologists attribute to evolution. However, one of the hallmarks of most scientific meetings was absent — the disagreement among proponents of different explanatory models. There were young-earth creationists presenting papers in breakout sessions who never addressed the discrepancies between their models of recent creation of organisms in their present forms and theistic evolution that Behe has claimed to accept, which would allow descent with modification from common ancestors over long time periods — at least for structures that were not "irreducibly complex", which was how Behe characterized most of the examples that the ID critics used to rebut his model.

DAIC showed the "big tent" strategy in operation. This approach makes ID more inclusive in order to increase the impact of the assault on evolutionary theory from a broad base of support. This may also be why details were so often missing from the presentations at the plenary sessions. All the anti-evolutionists in attendance may agree that evolution is bad and that apparent design in the universe is caused by an intelligent agent, but they do not agree on the specifics of time, place, frequency, duration, or intensity of this extranatural intervention. The devil, as they say, is in the details.

References

Elsberry WR. Book review of *The Design Inference* by William A Dembski. *RNCSE* 1999 Mar/Apr; 19 (2): 32–5.

National Academy of Sciences Working Group on Teaching Evolution [NAS]. *Teaching About Evolution and the Nature of Science*. Washington (DC): National Academy Press, 1998.

Wright MC, Joyce GF. Continuous *in vitro* evolution of catalytic function. *Science* 1997; 276: 614–7.

Zhang B, Cech TR. Peptide bond formation by in vitro selected ribozymes. *Nature* 1997; 390: 96–100.

Authors' Addresses

Jeff Otto
Genaissance Pharmaceuticals
5 Science Park
New Haven CT 06511
j.otto@genaissance.com

Andrew Petto
Division of Liberal Arts, University of the Arts
320 S Broad St
Philadelphia PA 19102-4994
editor@ncseweb.org

Design and Its Critics

Concordia University, Wisconsin June 22–24, 2000

Plenary Sessions

Is Design a Good Idea for Science?
Stephen C Meyer
(Whitworth Coll & the Disc Inst)
Michael Shermer
(Skeptics Soc & Occidental Coll)

Design in the Biological Sciences
Michael Behe (Lehigh Univ and the Disc Inst)
Scott Minnich (Univ of Idaho)
Ken Miller (Brown Univ)

Design in the Physical Sciences
John Leslie (Univ of Guelph, emeritus)
Robin Collins (Messiah College)
Brian Josephson (Cambridge Univ)

Design in the Public School Science Classroom
David DeWolf (Gonzaga Univ Law Sch)
Stephen Meyer
(Whitworth Coll & the Disc Inst)
Warren A Nord (U of N Carolina – Chapel Hill)
Ronald Numbers (U of Wis – Madison)
Commentator: Kenneth Miller (Brown Univ)

How to Detect Design
Michael Ruse (Univ of Guelph)
Del Ratzsch (Calvin College)
William Dembski (Baylor Univ & the Disc Inst)

Design's Philosophical Bona Fides
Patrick Henry Reardon (Touchstone)
Robert O'Connor (Wheaton College)
Michael Roberts (Chirk, United Kingdom)

Behe and His Critics
Mike Thrush (Univ of Notre Dame)
Larry Arnhart (Northern Illinois Univ)
Michael Behe (Lehigh Univ and the Disc Inst)

Panel Discussion – Prospects for Design

Paul Nelson (Discovery Institute)
Ted Davis (Messiah College)
Kelly Smith (Clemson)
Lenny Moss (Notre Dame)

Concurrent Sessions

Design in the Nineteenth Century
Jon H Roberts (Univ of Wisconsin – Stevens Pt)

Fine Tuning Arguments: For & Against
Allen Utke (Univ of Wisconsin – Oshkosh),
Tim McGrew (Western Michigan Univ)

A Third Way? Science Between Evolution and ID
Lothar Schafer (Univ of Arkansas), Jon Bogle (Lycoming College)

The Design Inference and the Future of Science
Lydia McGrew (Kalamazoo, Michigan); Robin Collins (Messiah College)

Design in the College Classroom
Mark Kalthoff (Hillsdale College), John Silvius (Cedarville College); Mary and Don Korte, Gary Locklair (Concordia Univ)

What Difference does Design make to Science?
Craig Rusbult (Univ of Wisc – Madison); Stephen Meyer (Whitworth College and the Disc Inst); Scott Minnich (Univ of Idaho); Paul Nelson (Disc Inst)

(*Further information on these sessions is available at <http://www.cuw.edu/Cranach/schedule.htm>.*)

Can Intelligent Design Become Respectable?

Kelly C Smith, Clemson University

[*At the* Design and its Critics *conference held at Concordia University in Mequon, Wisconsin, June 22–24, 2000, Kelly C Smith participated in the panel discussion on Prospects for Design. Professor Smith's paper is printed here with his permission; much of what he says here is covered in more detail in his article "Appealing to ignorance behind the cloak of ambiguity" in Robert T Pennock's forthcoming anthology,* Intelligent Design and its Critics *(Cambridge [MA]: The MIT Press, 2001).*]

I want to thank the organizers of this conference for inviting me here today, although I do rather suspect their motives. This is the very definition of hell for a philosopher — to be invited to a conference, to sit through 2 and a half days of really interesting presentations taking voluminous notes, a lot of which have marginalia attached to them like "no no no!" and "???", and at the very end to be told, "Okay, right! 15 minutes: vent your spleen all you want." Well, there is only so much I can vent. But I am going to try to get together a few basic thoughts I have had and offer them in some kind of coherent form.

What I want to try to do is give you a basic blueprint for respectability. If we make the assumption (and there are lots of people who would question this assumption, but I will make it for the purposes of this talk) that ID theory seriously wishes to become a respectable scientific theory, then I will tell you how to do it. If you follow my 4 simple steps to scientific respectability, you will get what you want: scientific respect, research funds, access to science classrooms, and so on, and so forth. It is actually fairly simple — all you have to do is follow the 4 steps. So what are they?

Step 1: Intelligibility

Well, the first step is a little complicated, but it involves *intelligibility*. I prefer not to talk about naturalism, but rather intelligibility. I think the one thing that scientists cannot compromise on — one of their most fundamental philosophical principles — is a commitment to intelligible causal factors. That is to say, they will not accept, in principle, explanations that make reference to causal factors that cannot be explained by human reason. Why does this matter? Well, it matters because it makes a big difference as to whether or not ID theory can be done within the context of science. I should add, by the way, that I fully grant that this is, in some sense, a philosophical assumption. It may be wrong. If you guys would like an admission that any of your favorite versions of creationism or ID theory could perhaps be correct, you have it from me. As a representative of the scientific orthodoxy, I will admit that they could, perhaps, be correct — but that is not a sufficient reason to believe them.

So can we practice ID theory as a science if we buy this notion of intelligibility? The answer is that it depends on what you mean when you talk about the designer. I have heard speakers here at this conference point out how it is necessary to specify the nature of the designer, and then some people in the audience say that it seems a bit unfair to require ID theorists to come up with a clear notion of what the designer is like. Well, this is *not* a tangential issue; it is a fundamental issue. An unwillingness to talk about this is going to cripple at the outset any attempt to make ID theory a scientific theory. And here is why. (Although I am not a theologian and I am aware of the fact that this is a horrendously complicated theological dispute, I am going to simplify egregiously.)

There is a large continuum of theories about God's nature, and on this continuum there are 2 basic endpoints. On one endpoint, you have a view of God as an intrinsically mysterious agent. Human reason is simply incapable of penetrating into the mysterious God's motives, mechanisms, and the like. On the other end of the continuum, there is God as a rational God, a God whose motives and mechanisms are analogous to those of human intelligence (a phrase that came up in an earlier talk). In other words, a rational God is a God that we can *understand* in some important sense of that word.

If we are talking about a rational God, I think that it is perfectly okay, in principle, to include theological hypotheses as part of a scientific theory. Now, for my evolutionist colleagues who are getting uncomfortable at this point, I would like to point out that there are going to be a lot of people out there who are not willing to accept what goes along with making God rational in this sense. But if you do, it is possible to include some kind of theology in scientific theory — Spinoza, for example, had a theological account that is not inconsistent with the sorts of claims scientists would normally want to make. But if you cite a mysterious God, you are inserting a factor in your explanation that is in principle inexplicable.

Paul Nelson just gave you the example of a professor's suddenly getting up and walking around a conference table as something that is not explained. Here is a good example of a fundamental confusion. Intelligibility is not a question of whether or not we *have explained* something, it is a question of whether or not it is *explainable* — is it, in principle, subject to explanation? I think someone's getting up and walking around the table is perfectly explainable. There are epistemic problems to be sure — it is not a trivial exercise to explain it. However, it is hardly *inexplicable*, and that is what makes it fair game for a scientific explanation. (As an aside, I should say that some of the confusion about whether ID theory is testable but false or untestable has to do with equivocal notions about the nature of the designer.)

A rational God has clear, practical consequences for a scientific theory. Suppose you posit a rational God and then assume that God designed the traits of organisms to maximize _____ (you are going to have to fill in the blank because I do not know what your particular rational God would want to maximize; I personally would tend to say something like "adaptiveness within a particular selective environment", but that is just me). Whatever goes in this blank, it seems we can then formulate a null hypothesis and say, "We expect God to be at least as good as a human engineer would be in designing traits to

maximize _____." Any trait that seems poorly designed from a human perspective would then represent a *prima facie* problem for an ID theorist. What you certainly cannot do in this kind of situation is to argue that it is simply a mystery why God created this trait in this particular way, because then all you are doing is reverting to a mysterious God.

I cannot really convince you right now why it is a good idea to buy into intelligibility. I would quickly say something like this, though: the consequences of not buying into this are far worse than you might think. To take what Winston Churchill said about democracy and apply it to neo-Darwinism, "Neo-Darwinism seems like a really bad theory — *until* you consider the alternatives".

Step 2: Internal Critique

The second step has to do with internal critique. You really can learn a lot about somebody by the people with whom they choose to associate. ID theory wants to be a "big tent" movement, but to fail to critique highly divergent arguments of colleagues who happen to share the same conclusion is tacitly to accept them. ID theory is not going to be a scientific discipline until it takes a clear stand on some major methodological issues. You simply cannot have a scientific discipline that talks about evolution but does not take a clear stand on the age of the earth or on common descent with modification! A scientific discipline shares, at least to some large extent, a certain common core of questions and methodologies. ID theory has no core methodology or theoretical commitments, and thus it is not yet a discipline (scientific or otherwise). Perhaps this can be remedied, but not as long some of your adherents persist in making the ambiguity of your own positions a defensive virtue, as when a critique is deflected with, "Well, you know, we don't *all* say that." If ID theorists themselves do not take a consistent stand, they are certainly not entitled to complain about the imprecision of their critics over the very same points!

So it seems as though there are 2 alternatives here: either you can institute a thorough, rigorous system of internal critique and try to develop a consensus along some of these issues, or you can fragment into separate groups, each group having a relatively unified approach to these kinds of things. Either will accomplish what I have called "internal critique".

Step 3: External Critique

The third step has to do with external critique — with stepping away from over-reliance on critiquing your opponents. When I teach basic philosophy classes, I have my students write argumentative papers. I want them to understand that critical ability is extremely important — it is something that they hone in a philosophy class, if nothing else. But I also want them to understand that there is a fundamental difference between critiquing your opponent and demonstrating your own position. This is a fundamental distinction that ID theorists need to take more seriously.

There are lots of reasons to keep the two activities clearly separate. First, it is always easier to be negative than positive. Given that any complicated theory is going to have anomalous data, anybody can find interesting cases to harp on. This does not really prove a whole lot. Second, it is just too tempting to engage in distortions of what your opponent says (straw man arguments). This is particularly true if you believe *deeply* in what you're saying — this makes it extremely difficult to be fair to your opponent, who you "know" is completely wrong. I do not see a whole lot of evidence, to be perfectly honest with you, that there has been a change in some of these practices since the bad old creationist times.

Third, it may very well be that you are implying a false dichotomy. The underlying assumption when you substitute critique for demonstration is that, if my opponent is wrong, then I must be right. But there may well be a third alternative. Suppose it turns out that neo-Darwinism, whatever that means (people define this term in lots of different ways for different purposes), is wrong. It does not necessarily follow that ID theory is right, unless those are the only 2 alternatives, and believe me, there are more.

Finally, it draws attention away from a basic practical fact (that it is practical makes it no less important). *Nobody* is going to abandon an extremely fruitful scientific theory until there is a viable alternative that does as much or more. It is just not going to happen. I have been in a position of espousing a theory on the outside of orthodoxy, and I understand that it can be frustrating, but at some point you have to shift away from whipping up the crowd by complaining about your lot versus the orthodoxy to coming up with a theory that works.

Step 4: Novel, Testable Hypotheses

And that gives me a segue into my last and probably most important step, that ID theory really has to start generating novel, testable hypotheses (and then testing them). Now, I am a philosopher, so I am perfectly aware of all the dilemmas that arise if you try to make testability some sort of touchstone for science. I am not saying that. I am not a logical positivist. But I think it is clearly true, however you want to characterize it, that testability is a critically important element of successful scientific theories. Therefore, if ID theory is going to be a successful scientific theory, it must generate testable hypothesis — and note here I am also saying testable *hypotheses* (I am not talking about the theory's being testable itself. That is a can of worms I would rather not open right now).

The basic reason for this is pretty simple. We are clever and creative explainers. It is very easy for us to sit in a dark room and convince ourselves, based on *a priori* principles and data that are already in front of us, that we have the correct explanation. The only way we can really know whether or not our explanation is right is if we make novel predictions and then go out and see if they are met. That is the function of testability. As far as I can tell, ID theory just does not do this. There might be, maybe, some very minimal claims you can make about the heuristic value of ID theory — one of the talks, for example, postulated that perhaps the design heuristic is akin to notions such as beauty in evaluating scientific theories. Even if I were to grant that, this claim does not put ID anywhere close to the status of a developed scientific theory. We do not teach beauty in elementary science classes as a way of talking about scientific theories, and for very good reason. It is, at best, an interesting subtlety you get into when you talk about the philosophical aspects of science. It is *not* a fundamental theory in itself.

I think that nothing shows the difference between ID theory and its orthodox opponents better than a comparison of professional conferences. If I go to the annual meeting of the Society for the Study of Evolution, and I bring a bunch of graduate students who want to do research in evolution, I can point them in any direction and they can go and find hundreds of seminars going on, each

Intelligent Design in the Classroom?

Kenneth R Miller, Brown University

[At the Design and its Critics *conference held at Concordia University in Mequon, Wisconsin, June 22–24, 2000, Kenneth Miller (Brown University) was the commentator at the plenary session on Design in the Public School Science Classroom. The speakers were David DeWolf (Gonzaga University Law School) and Stephen Meyer (Whitworth College and the Discovery Institute), Warren A Nord (University of North Carolina at Chapel Hill), and Ronald Numbers (University of Wisconsin at Madison). The following excerpt from Professor Miller's extemporaneous comments is printed here with his permission.]*

I was surprised to hear Professor DeWolf fundamentally confuse two legal issues. He talked about the acceptance of scientific evidence by the Supreme Court. And he said that the Court's acceptance of scientific evidence has changed from requiring that the scientific evidence be the prevailing scientific view to simply allowing any method that sort of follows the methods and procedures of science. The interesting thing about this assertion is that it has nothing to do with the suitability of scientific teaching in the classroom; it simply has to do with the taking of testimony in tort cases, in lawsuits. And it was designed to allow the broadest possible interpretation to come in, so that a jury could judge the evidence in a court case. And it seems to me that what is admissible as authentic science in education is quite a bit different from what testimony is allowable in a tort case, and I do not understand how someone as experienced in the law as Professor DeWolf could confuse the two of those.

It was pointed out that there is another Supreme Court decision related to viewpoint discrimination, so called, and I clearly heard the first pair of speakers [DeWolf and Meyer] implying that the exclusion of intelligent design from the science classroom was an example of viewpoint discrimination, thus once again confusing important legal issues. The "viewpoint discrimination" in question had to do with viewpoints allowed by school-funded groups, not viewpoints in the classroom curriculum. As a scientist, I would argue that the entire scientific enterprise is, in fact, an enterprise of viewpoint discrimination. And what I mean by that is that there are indeed viewpoints we discriminate against in science — meaning that we rule them out — including things like the notion of a flat earth, the notion of a geocentric or earth-centered universe, and purely spiritual theories of disease that suggest that the black plague, cancer, and tuberculosis were due to spiritual defects. Koch, Pasteur, and others advocated a germ theory of disease that explained those quite nicely. Viewpoints to the contrary we do indeed discriminate against, because we regard them as being unscientific and in many cases disproved.

One of the tests put forward by Dr Meyer of whether or not intelligent design theory was appropriate for the classroom, and I think I have this right, was how many scientists take the theory seriously. And clearly, he felt that if a sufficient number do take it seriously, then intelligent design theory should be put in the classroom. Now the interesting thing about that is, as Professor Numbers pointed out, is that when you do systematic searches for the number of papers on intelligent design theory or irreducible complexity that have appeared in the scientific literature, the number that usually comes up is 0. And what this suggests is that these points of view have not made any sort of case in the scientific community.

Meyer then said, well, even if not many *scientists* take it seriously, the important thing is that these are "controversial" issues. These are issues that are sufficiently controversial that they have drawn 300 of us here; and if there is legitimate controversy, and this is a legitimate controversy, you therefore ought to teach the controversy. Now, I point out that if we had a conference somewhere else, on astrology, we could likely draw many more than 300 people to it. Nonetheless, we would not propose that, therefore, we should teach astrology as an alternative to astronomy. We also do not propose that our medical

---

of which has all kinds of evolutionary ideas, testable hypotheses, new methodologies based on evolutionary reasoning. They can go out there, they can find research projects, they can go back to the lab, and they can go to work. This ID conference, on the other hand, really does not have a single session presenting testable hypotheses. There was one that, in a way, sort of, kind of, made allusions to testable consequences, but I can say firsthand that there was nothing discussed in this session that neo-Darwinism had not already predicted. So there is really no practical import to ID theory that I can see.

Now, in case people are tempted to say, "Ah, well, give us some time, we'll figure this out", let me suggest that there clearly *are* testable consequences right now. Any relatively bright graduate student should be able to sit down with a pencil and a piece of paper and come up with some for you pretty quickly, and then you have got a research project. In case you cannot find anybody like that, allow me to offer your first testable hypothesis.

A lot of ID theorists (and again we run into the ambiguity problem) have absolutely no problem accepting the theory of population genetics as a microevolutionary theory. But they do not like to accept macroevolution. They believe that there are certain natural kinds, or species, or whatever, and there are boundaries in between the kinds that cannot be overcome. In other words, population genetics works, but it cannot push allele change past these postulated boundaries between kinds. The existence of such boundaries is not a prediction of population genetics, and there is nothing in population genetic theory that would even lead one to suspect such bounded change. So, if this ID view is correct, there should be populations left and right that meet all the population-genetic criteria predicting evolution, but that are in fact not undergoing evolution. It should be a relatively straightforward job to go out and confirm experimentally the existence of these populations.

Now, let me just insert a caveat here because I worry about having my words taken out of context. The populations you find have to meet *all* the population genetic criteria. There are cases one could point to that might *seem* on superficial examination to meet all the criteria, but really do not. I have in mind something like sickle cell trait. When people first dis-

schools should include the inclusion of Christian Science faith healing as an alternative to scientific medicine.

Incidentally, I heartily endorse Warren Nord's call for courses in comparative religion at the high school level. Religious studies are very important at the university level; I think that they are a fundamental part of the liberal education. He and I stand foursquare together on that one, and I think that it would be very important to do exactly the same thing at the high school level. But again, we would not say that because some people are witches and practice witchcraft, we should promote an artificial equivalence of witchcraft to established religions. And for that matter, we should not — merely because there is controversy in the minds of some — equate Holocaust denial to the authentic history of the Holocaust in the World War II era. And I do not think that anybody here would advocate that. The very existence of a controversy is not sufficient reason to teach it, when we think that controversy has no standing.

Finally, and this is really my last comment, how does new science actually find its way into the scientific classroom? Science changes over time. Scientific textbooks are constantly rewritten. New discoveries get in them time after time after time. In fact, today, as many of you know, the end of the initial phase of the Human Genome Project has just been announced by Celera and by the National Institutes of Health. That announcement, I assure you, is going right into every textbook that every author is in the process of writing or imagining.

So how does new science get into the textbook? The answer is, it gets in by winning the scientific consensus. When you decide what should be presented in the classroom, what you want to present in terms of astronomy or earth science or chemistry, is the scientific consensus on a point of view. That consensus should never be taught dogmatically; it should always be taught as tentative and subject to revision, because all science, including evolution, is tentative and subject to revision. But the fact of the matter is the way these new things get in is not by an act of Congress, not by an act of the state legislature, not even by an act of the state board of education. Rather, they get into the classroom, into the curriculum, and into textbooks by winning the battle for the scientific consensus.

And it is in the culture of science — the American Astronomical Society, the Geophysical Union, the American Society for Biochemistry, the American Society for Cell Biology (to which I belong) — that new ideas have to stand or fall. Bad science is routinely filtered out. Science that wins is not always correct, but it certainly has the scientific consensus behind it. And therefore, what I would urge the advocates of intelligent design to do is the sorts of things that real scientists do, and that is to forswear political action. Do not petition legislatures or state school boards, but simply to show up at scientific meetings, present papers, and argue the case in front of other scientists. Science is an open community, an open society, and if you win the scientific consensus, or even if you get a strong minority view, you will have papers, you will have peer-reviewed publications, you will have reasonable grounds, and you will begin to convince people.

As it turns out, however, the strategies that have been taken just in the last year against evolution have been in an entirely different direction: they have sought the protection of government. What I mean by that is that by acting through the government, the intelligent design movement has achieved temporary success in Louisiana, and limited success in Oklahoma, in putting disclaimers about evolution inside textbooks. Other movements have succeeded in getting state boards of education to remove evolution from the science curriculum in Kansas and also in Illinois. Illinois nobody noticed, but it certainly happened there, and similar moves are under way in a variety of other states. And what bothers me as an educator is to see people basically forswearing the scientific community as a venue in which to advocate what they claim are scientific ideas and instead choosing the agencies of government, sort of jumping around building a nonscientific consensus to get these ideas in the classroom.

Thomas Jefferson once observed that "Error alone requires the assistance of government. The truth can stand on its own." I think that is a good way to put my point.

Author's Address

Kenneth R Miller
Department of Biology
Brown University
Providence RI 02912

covered sickle cell trait and did population genetics on it, it was a bit of a mystery why the sickle cell allele was so common in the population. People knew that in its homozygous form it was highly deleterious, so they calculated the selection coefficients based on this and said, "This is very strange — there are a lot more of these alleles floating around in the population than we would expect." This puzzle led to an investigation to see what other factors were at work in the population. As it turns out, the sickle cell allele confers an advantage in the heterozygous condition, so people who have only one copy of the sickle cell allele are more resistant to malaria, and in certain parts of the world that is a very good thing. After discovering this, the geneticists adjusted their selection coefficients and re-did the calculations, and it works perfectly. So I am not talking about superficially analyzed populations that appear not to undergo evolutionary change. I am talking about a situation in which you have excellent data on the population genetic variables and they simply do not add up.

The Road Ahead

In conclusion: Personally, I find it highly unlikely that my advice is actually going to be put into effect. The fact that I am here means that I am an optimist about these kinds of things. But I strongly suspect, despite what some speakers have said, that there are *a priori* but unspoken commitments that people here are just not willing to violate. In particular, I think that there are a lot of people here who are unwilling to accept the fundamental philosophical commitment science must make to intelligible causal factors (theological or otherwise). To do so would open a big can of theological worms that a lot of people do not want to get into, and I understand why not. And lastly, I do not have a lot of faith, to use a loaded word, that people who take ID theory seriously are actually going to be able to generate novel, testable hypotheses based on their beliefs. However, I am struggling to remain open-minded, and I welcome any efforts anyone wants to produce along these lines.

Evolution: How Does It Fare in State K–12 Science Standards?

Lawrence S Lerner

"Accountability" has been the buzzword in public education for a decade or more. As a consequence, there has been much activity in writing curriculum standards — documents that list what students are expected to know at various grade levels from kindergarten through high school. In late 1997, I was asked by the Thomas B Fordham Foundation to assess the quality of the 36 state science standards then in existence. My report was published in March 1998 (Lerner 1998a) and summarized in this journal shortly thereafter (Lerner 1998b)

Things moved fast after that. By late 1999, so many state standards had been published, revised, or rewritten that a new standards review was prepared for publication in January 2000. By that time, 49 states had science standards. The 50th state, Iowa, does not publish any of its curriculum standards.

In the course of these studies of science standards, it became clear that evolution was a touchy topic, as evidenced by the treatment to which it was subjected in not a few states. It also became clear, moreover, that I had been quite wrong in what I had written in *RNCSE* in 1998:

> Moreover, except for the issues surrounding the teaching of evolution that arise in a relatively small number of states, the sciences do not seem to be plagued with the political–ideological infighting concerning content that characterizes some of the other areas, notably history and English literature.

Indeed, politics had impinged on instruction in most if not all subjects taught in the schools, science not excepted. This was made explicit in two recent publications which reviewed such political pressures throughout the curriculum (Gross 2000; Levitt 1999). We therefore resolved to make a special study focused on the treatment of evolution and the consequences thereof for science instruction in general. This study (Lerner 2000) was published in September 2000.

It is perhaps repeating the obvious to note that proper teaching of evolution is crucial to decent instruction in the life sciences, for which it is the central organizing principle. Readers of this journal will understand why proper teaching of evolution is so important to science instruction in general as well as to the historical sciences — biology, geology, and cosmology — in particular. With this in mind, I constructed a list of things students ought to learn about evolution as they move from the primary grades (for example, offspring are similar to but not exactly like their parents) through the middle grades (for example, variability among individuals of a species leads to differential survivability in a given environment) to the high-school grades, where a comprehensive, explicit treatment of evolution across all aspects of the biological sciences is appropriate (Gross 2000).

In responding to creationist pressures to obscure or eliminate evolution from their standards, some states have used one or more ploys. The most common are these:

- The standards include many of the central principles of evolution — usually briefly — but the word *evolution* is carefully avoided. Inaccurate and misleading euphemisms such as "change over time" are used instead of the "E-word".
- Biological evolution is simply ignored. Geological evolution, the history of the solar system, and cosmology may well be treated, often even employing the word "evolution". Fossils are sometimes mentioned, but only in the context of geology, not biology.
- Evolution of plants and animals is treated to some degree but human evolution is ignored.
- All scientific discussions that imply an old earth or universe are deleted. Kansas is the only state to do this completely, but Mississippi, Tennessee, and West Virginia come close.
- Creationist jargon is used. In Alabama, all textbooks are required to carry a disclaimer that calls evolution "controversial" and labels it "a theory, not a fact". The disclaimer also cites a number of other standard creationist ploys. The details of this approach are discussed below.
- Some or all of the historical sciences are treated lightly but no attempt is made to elucidate the connections among them.

With both the requirements of good instruction and the strategies above in mind, I assembled a list of criteria that could be evaluated on a point scale. The criteria were:

- Is the "E-word" used where appropriate? (0 – 20 points)
- Is biological evolution treated properly? (0 – 40 points)
- Is human evolution treated? (0 – 10 points)
- Is geological evolution treated? (0 – 20 points)
- Is cosmology treated? (0 – 10 points)
- Are the connections among the his-

TABLE I: DISTRIBUTION OF GRADES FOR TREATMENT OF EVOLUTION

Grade	A	B	C	D	F	F-minus
Number of States	9	15	7	6	12	1
States	CA, CT, IN, NJ, NC, RI, SC, DE, HI,	CO, MN, VT, WA, MI, AZ, ID, MA, MO, MT, PA, OR, SD, UT, DC	MD, NM, NV, NY, NE, LA, TX	AR, KY, WI, VA, AK, IL	WY, ME, OH, OK, NH, FL, AL, ND, GA, MS, TN, WV	KS

Lerner Report Announced at AAAS/Fordham Symposium

Eugenie C Scott
NCSE Executive Director

Lawrence Lerner's *Good Science, Bad Science: Teaching Evolution in the States* was released to the public at a day-long symposium co-sponsored by the American Association for the Advancement of Science and the Fordham Foundation on Tuesday, September 26, 2000. Held at the AAAS building in Washington, DC, the symposium drew close to 100 people and many members of the press. The symposium, "The Teaching of Evolution in US Schools: Where Politics, Religion and Science Converge", included scientists, educators, politicians, researchers, clergy, and reporters among its speakers.

Lerner opened the symposium by presenting a summary of his report, which was then discussed by scientist Paul Gross, author of another Fordham report on science education; Lisa Graham Keegan, Arizona State Superintendent of Public Instruction (who was then under consideration by President-elect Bush for Secretary of Education), Warren Nord, an "intelligent design" creationism proponent from the University of North Carolina at Chapel Hill, and me. The teaching of evolution, evolution and religion, educational politics, and the public understanding of science were discussed in other panels. It was an all-day symposium, attended by approximately 100 people at any one time.

One panelist, the Reverend Barrett Duke, Vice President for Research, Ethics, and Religious Liberty Commission of the Southern Baptist Convention, startled the audience, composed mostly of scientists, by bluntly pointing out that conservative Christian organizations were "placed to make a difference". They have large memberships and budgets, their publishing houses have good sales, and they are not going to "go away on this subject". He claimed that Southern Baptists are "more aware of weaknesses" in evolution, being familiar with new questions raised in biochemistry and probability theory by Michael Behe and others. He stated that these arguments show the improbability of evolution, adding that it takes more faith to believe that single-celled organisms could become human beings than to accept biblical creationism. He pledged that the Southern Baptists would be promoting prayer legislation and legislation requiring the posting of the Ten Commandments in public schools. His approach towards evolution contrasted strongly with that of fellow panelists David Byers of the US Catholic Conference's Committee on Science and Human Values and evangelical Christian Dr Edward B Davis, historian of science from Messiah College and *RNCSE* contributor, both of whom spoke of the acceptance of evolution in mainstream Christian and some evangelical traditions.

A press conference was also held, attended by 15–20 journalists. Once the story went out over press wire services, newspapers in virtually every state ran headlines boasting or bemoaning the "grade" given by Lerner to their states' public schools' treatment of evolution.

---

torical sciences treated? (0 – 10 points)

- Is creationist jargon used? (-20 – 0 points)
- Is a textbook disclaimer mandated? (-25 – 0 points)

Each of the 49 states (and the District of Columbia) that have science standards was thus rated and assigned a point score, which was translated into the traditional letter grades A through F. (Kansas, the only state to achieve a *negative* score, was awarded a disgraceful F-minus.) Table I shows the distribution of letter grades. In each category, the states are listed in the order of their scores.

In the absence of such an evaluation, it would be easy — and wrong — to guess that the states treating evolution poorly are mainly in the Bible Belt. There is indeed a concentration of poor performance in those states, but the reality is more complex. North Carolina, South Carolina, and Indiana, on the one hand, have standards that treat evolution excellently, and Louisiana and Texas squeak by with very mediocre but acceptable treatments. Maine, New Hampshire, Wisconsin, and Illinois, on the other hand, have poor-to-bad standards. Good science education is not simply a geographical issue. This is important, because it is a snobbish as well as damaging misconception to shrug one's shoulders and write off the inhabitants of this or that region as incorrigible or ineducable.

The good news is that 31 states — just under two-thirds — achieved passing grades. But we should not be too sanguine about this. Given the abundance of educational models and the wide variety of approaches to excellence that they offer, there is no reason for any state to do less well than the 6 that achieved perfect scores and the 3 others that came close.

Fortunately, the activity in standards writing and revision has not flagged; many states are busy with improvements. Arizona and New Mexico have only recently fought off creationist attempts to remove evolution from their state standards. As is well known, the voters of Kansas have unceremoniously dumped enough creationists from their state board of education to give strong expectations that Dorothy will soon return from Oz. And there are signs of constructive activity in other poorly rated states as well. On the other hand, the most recent changes in Pennsylvania's proposed science education standards weakened the presence of evolution by introducing inappropriate qualifiers and "hedges" in several sections.

This is not to say unbridled optimism is warranted. Creationism has repeatedly waxed and waned over the United States ever since the notorious Scopes trial of 1925, and will doubtless continue to do so. In particular, the "intelligent-design" creationists are making a vigorous and well-funded effort to influence public-

The Creationist Response

Glenn Branch, NCSE Office Manager

The Fordham Foundation's report *Good Science: Bad Science: Teaching Evolution in the States* received wide media coverage. In addition to national coverage, local newspapers and news stations eagerly announced how their states had fared, exulting in As and deploring Fs. Not surprisingly, the more media-savvy creationists lost no time in responding to the report as well.

Jonathan Wells and Jay Wesley Richards of the Discovery Institute's Center for the Renewal of Science and Culture posted a brief response entitled "Lerner Report whitewashes bad science" on the CRSC's web site (also available from <http://www.arn.org/docs/wells/jw_lerner1000.htm>). A modified version appeared under the title "Natural selection found in report on science education" in the Washington *Times* (October 8, 2000). Their colleague Stephen C Meyer, director of the CRSC, published a similar opinion piece, "'E' is for evolution; 'F' is for Fordham", in the Kansas City *Star* (October 16, 2000).

The CRSC's "Lerner Report whitewashes bad science" was partially recycled from, and made reference to, Wells's recent book *Icons of Evolution* (Washington DC: Regnery Publishing, 2000). In prepublication publicity for *Icons*, the CRSC released Wells's "An Evaluation of Ten Recent Biology Textbooks", which eventually appeared as an appendix to Wells's book. Unfortunately, versions of Wells's evaluation of the state of evolution education appeared cheek-by-jowl with reports of the Fordham Foundation's report — a particularly egregious case was that of *USA Today*, which devoted almost exactly the same amount of space to both evaluations in the same article ("19 states get a bad grade for their teaching of evolution", September 27, 2000, p 11D).

On the young earth side, Answers in Genesis posted a lengthy critique entitled "Who's really pushing 'bad science'?" on its web site (<www.answersingenesis.org/news/lerner_resp.asp>). AIG promises that a printed version will be available shortly. The critique is by Jonathan Sarfati, who also wrote *Refuting Evolution*, which purported to respond to the National Academy of Sciences' *Teaching About Evolution and the Nature of Science*. The press release advertising Sarfati's critique was headed "AiG gives anti-creationists an 'F-' grade"; it concluded with the delightful pun, "If you really want your children to be 'learners', don't let Lerner have the upper hand!" (<www.answersingenesis.org/docs2/4369news10-4-2000.asp>).

NCSE did not go unmentioned. In the press release for *Icons of Evolution*, its publisher, Regnery Publishing, claims that the book reveals "How a so-called 'science education' organization pressures public schools to prohibit any criticism of Darwinian evolution — then calls on the ACLU to threaten an expensive lawsuit if a school district resists the bullying." AIG was more forthright: in discussing the bibliography to the Fordham Foundation report, Sarfati refers to "the so-called National Center for Science Education (which does nothing but push evolution and bash creation)".

---

school science teaching at every level. To date their successes have been limited, but they seem to be gradually shouldering out the more traditional but less sophisticated young-earth creationists who, up to the present, have had much more influence. Nevertheless, most young people in the United States have a fair chance to learn biology, and by extension, the other sciences as well.

[*All Fordham Foundation publications cited below are available at <http://www.edexcellence.net>; single free copies may be obtained by calling the toll-free number 888-823-7474.*]

REFERENCES

Gross P. *Politicizing Science Education.* Washington (DC): The Thomas B Fordham Foundation, 2000.

Lerner LR. *State Science Standards: An Appraisal of Science Standards In 36 States.* Washington (DC): The Thomas B Fordham Foundation, 1998a.

Lerner LR. K–12 science standards, state by state, *Reports of the National Center for Science Education* 1998b Jan/Feb; 18(1): 25–6.

Lerner LR. *The State of State Standards 2000.* Washington (DC): The Thomas B Fordham Foundation, 2000.

Levitt N. *Prometheus Bedeviled,* New Brunswick (NJ): Rutgers University Press, 1999.

WEB LOCATIONS VISITED IN THIS ISSUE

NEWS ITEMS

TOPIC Misquotations on the Web
OWNER Wesley Elsberry
LOCATION <http://inia.cls.org/~welsberr/evobio/evc/quotes.html>
LAST VISIT January 29, 2001

TOPIC The Michael Polanyi Center Peer Review Committee Report
OWNER Baylor University
LOCATION <http://baylor.edu/pfd/001017polanyi.pdf>
LAST VISIT November 15, 2000

TOPIC Creeping Creationism In PA Science Standards
OWNER Pennsylvania Department of Education
LOCATION <http://www.pde.psu.edu/standard/science.pdf>
LAST VISIT February 15, 2001

TOPIC Creeping Creationism In PA Science Standards
OWNER WHYY
LOCATION <http://whyy.org/rameta/RT/RT20001221_20.ram>
LAST VISIT February 15, 2001

TOPIC Criticisms of the Alabama Disclaimer
OWNER NCSE
LOCATION <http://www.ncseweb.org>
LAST VISIT February 15, 2001

FEATURES

TOPIC Darwin Day 2001
OWNER Darwin Day
LOCATION <http://www.egroups.com/group/darwinday>
LAST VISIT November 15, 2000

TOPIC Design and Its Critics Program
OWNER Cranach Institute
LOCATION <http://www.cuw.edu/Cranach/schedule.htm>
LAST VISIT November 15, 2000

TOPIC Evolution: How Does It Fare in State K–12 Science Standards?
OWNER Thomas B Fordham Foundation
LOCATION <http://www.edexcellence.net>
LAST VISIT November 15, 2000

INSTRUCTIONS FOR CONTRIBUTORS

Reports of the National Center for Science Education (RNCSE) welcomes contributions from its readers and from anyone interested in issues related to evolution as the foundation for the biological sciences, to the place of evolution in the science curriculum, or to the public perception of scientific method and practice. These contributions may be submitted in one of two forms.

News, commentaries, and features describe events or experiences that we wish to relate to our readers and members. These may include reports of school-board elections or local organizing by parent and teacher groups, political or governmental decisions and policies, first-person accounts of experiences with anti-evolutionist speakers, curricula, or organizations, other reports of information related to our primary concerns of promoting good science in education and public life, and, of course, humor related to creation/evolution issues.

Articles include book reviews, scholarly articles, and formal essays. These may explore specific arguments raised by anti-evolutionist scholars, relate new information that may be helpful in promoting evolution, or present original research related to the public understanding of evolution. We also welcome case reports and classroom action research that assess the outcome(s) of strategies for strengthening the understanding of evolution in educational practice.

All articles should be written for a general audience, and authors should provide definitions or descriptions for technical terms and concepts that might not be understood by a non-specialist. All article manuscripts are submitted to reviewers for comments on their technical content and suitability for a general audience. Acceptance for publication does not take into account the author's formal academic background or profession. We encourage query letters from any prospective author.

Style and Format

The following requirements apply *only* to articles and major features (longer than 4 manuscript pages):

1. Manuscripts must be typed double-spaced, including inset quotations and references. Margins must be adequate for editorial notation.

2. Manuscripts should not exceed 20 double-spaced typewritten pages and must be accompanied by a brief biographical statement identifying the author(s) and giving an address where interested readers may contact the author(s).

3. A printed original and two copies should be supplied by the author(s). Names of the author(s) should appear only on the cover page if blind review is desired. Manuscripts submitted on computer diskette will greatly expedite the editing and publication process. Acceptable diskette formats include (standard or high density 3.5-inch) WordPerfect 5.1, MS-Word, or ASCII formats in DOS/Windows versions and MS-Word 6.0, Claris Works 5.0, or plain text for the Macintosh. Manuscripts and other notes submitted by electronic mail should be in plain text format. Please contact the editorial office for information about other word processing and diskette formats that might be acceptable.

4. Citations within text referring to reference section should be limited to author, date and (when appropriate) page, for example (Smith 1982: 21). Multiple references within text appear in chronological order, for example, (Thomas, Peters, and others 1925; Smith 1943, 1947; Smith and Jones 1983a, 1983b, 1984). Citations of electronic resources should include author(s) and date accessed. References to internet locations should be enclosed in angle brackets, for example, <http://www.ncseweb.org>.

5. Reference sections are alphabetical and should conform to the citation-sequence format in *Scientific Style and Format: The CBE Manual for Authors, Editors, and Publishers*, 6th ed., illustrated in the following examples:

   Kehoe AB. Modern anti-evolutionism: The scientific creationists. In: Godfrey LR, ed. *What Darwin Began*. Boston: Allyn and Bacon; 1985. p 165–85.

   Kuban GJ. Sea-monster or shark? An analysis of a supposed plesiosaur carcass netted in 1977. 1997; Available from <http://members.aol.com/paluxy2/plesios.htm>. Last accessed March 28, 1997.

   Smith FZ. Geocentrism re-examined. *Journal of Nice Things* 1985; 21 (3): 19–35.

   Waters IC, Rivers HI, and others. Swept away in a flood of enthusiasm [editorial]. *Reports of the National Center for Science Education* 2995 Jan-Feb; 1015 (1): 22–9.

   Zubrow E. *Archaeoastronomy*. Orlando (FL): Academic Press, 1985.

   Do not abbreviate names of publications. Include location of book publishers, and use the abbreviation "nd" for undated material. Multiple entries by the same author are listed in the bibliography in chronological order and those in same year are listed as: 1982a, 1982b, and so on.

6. Material formatted as footnotes or endnotes should be incorporated into the text or deleted.

7. Text abbreviations based on non-English terms should be translated into the appropriate English equivalent. For example, *e.g.* should be rendered as *for example*.

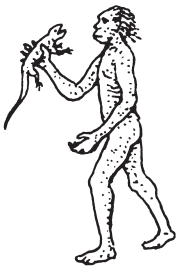
8. All measurements reported in scholarly and scientific articles are to be expressed in SI or "metric" units.

9. Figures, plates, or diagrams should be submitted in camera-ready form or provided in that form upon acceptance. Submission of these materials and of quotations by writers presumes that authors have obtained permission to use these potentially copyrighted materials. Photographs should be glossy prints and should be accompanied by permissions when appropriate.

10. Authors should retain copies of all manuscripts, photographs, and figures submitted; NCSE assumes no responsibility for materials submitted.

11. All submissions are subject to editorial correction of grammar, spelling, punctuation, and consistency as per *Scientific Style and Format: The CBE Manual for Authors, Editors, and Publishers*, 6th ed. All manuscripts are edited prior to publication

12. Manuscripts cannot be returned unless accompanied by stamped, return-addressed envelopes.



NATIONAL CENTER FOR SCIENCE EDUCATION
PO Box 9477
Berkeley CA 94709-0477

Change Service Requested

Non-Profit Org.
U.S. Postage
PAID
Permit 1197
Berkeley CA

20(4)

Membership in the National Center for Science Education brings you

- One year's subscription to *Reports of the National Center for Science Education* (6 issues)
- Participation in NCSE's diverse efforts to promote and defend the integrity of science education

MEMBERSHIP / SUBSCRIPTION / DONATION

Name

Address City State Zip

Home Phone Work Phone

Occupation

☐ Check here if NCSE may share your name with activists in your state
☐ Check here if you object to our sharing your name with other nonprofit organizations

NCSE MEMBERSHIP **ONE YEAR** US: $30 Foreign: $37 Foreign Air: $39 **LIFETIME** $600	$
TAX DEDUCTIBLE CONTRIBUTION TO NCSE	$
BACK ISSUES *NCSE REPORTS / C/E Newsletter* (Vol 1–16, $3 per issue; $18 per volume; all 18 vols, $300) *C/E Journal* (1–9 copies, $6 each; 10 or more, $5 each; full set, nrs 1–39, $150) *RNCSE* (Vol 17–19, $4 per issue; $24 per volume)	$
SHIPPING $1 for 1 issue; add $.75 for each additional issue; maximum of $10 — even for all 39 back issues.	$
TOTAL ☐ Check (US dollars) Charge to: ☐ VISA ☐ MasterCard	$

Credit Card Number Expiration Date

Name as it appears on card

Signature

SUBSCRIBER INFORMATION
Subscriptions are fully tax deductible. NCSE is tax exempt under Federal IRS Code 501(c)(3) and the corresponding provisions of the California law. Amounts paid to NCSE are tax-deductible to the extent permitted by law.

MISSING ISSUES
If your issue fails to arrive or is badly damaged in transit, send us the date of issue and we will rush you a replacement.

MOVING TO A NEW ADDRESS?
Let us know your new address as early as possible and we will update our records of your subscription accordingly. Please allow 4 weeks for an address change.

Please mail all correspondence about your subscription to:

NCSE
PO BOX 9477
BERKELEY CA 94709-0477
(510) 601-7203 (800) 290-6006
NCSE@NCSEWEB.ORG

Printed on recycled paper.